**PhD Proposal**
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Jo Bailey
300432267

Working title:

# Engagement by design: *Engagement through design*

## *Design approaches to foster reflexive science communication*

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Victoria University of Wellington

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TE WHARE WĀNANGA O TE ŪPOKO O TE IKA A MĀUI
VICTORIA
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Te Pūnaha Matatini
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# Abstract

**In recent years, science communication** in Aotearoa New Zealand has been increasingly funded, celebrated and rewarded. Yet, many activities are undertaken (both by scientist-communicators at the individual level and by research networks at an organisational level) based largely on instinct, personal preference or on anecdotally well-received prior activities. Within Aotearoa New Zealand's inter-institutional, cross-disciplinary research networks such as Centres of Research Excellence (CoREs), 'public engagement' is explicitly stated as an objective both in foundational documents and within performance and management frameworks, yet it is not clear that there is a standardised or uniform understanding of what 'engagement' entails, how it relates to other terms like science communication and outreach, or how it should be reported and measured.

Literature from social science fields such as Public Engagement with Science and Technology (PEST) over the past two decades has advocated a dialogical approach to engagement; 'a two-way dialogue', ultimately (or ideally) allowing public(s) to have input into policy and research direction, and exploring with scientists the social licence for emerging areas of science and technology. In addition, there have been calls for greater reflexivity as a way to raise the calibre of PEST activities. The extent to which either of these things happen in practice is variable, and under-documented in the Aotearoa New Zealand context.

This highlights a gulf between the theory of science communication (from fields such as Science and Technology Studies and PEST) and the practice of science communication ('the doing' in terms of development and delivery of strategy and the interface with audiences/participants/public(s)).

If social sciences bridge the rational analysis of the natural sciences and the interpretive enquiry of the humanities, then design sits *outside* both – a 'third culture', which offers a useful perspective. Design is a multifaceted discipline, with a broad range of objectives, from explanatory to affective. This project will draw on practices including research through design, design reflexivity, critical design and human-centred design or design thinking. It seeks to examine if design, as a user-centred approach to problem-solving, can offer opportunities to improve PEST, both strategically and practically, through providing insight into the public engagement landscape in Aotearoa New Zealand, and connecting theory and practice.

Jo Bailey (yes, that's me). My website is makinggood.design

# Personal values statement

*When I wrote my MDes thesis (Bailey, 2014), I had a nascent interest in reflexivity (though I didn't know it as such at the time) as I sought to probe what 'ethical practice' meant to me. Now, as part of my doctoral research I am exploring reflexivity as a tool, and for me, that involves an openness about myself, my process, and my perspectives. This is an evolved version of the statement I wrote about myself back in 2014. I am including it here as it defines a beginning in my experiments with reflexivity in the context of this project:*

In the introduction to her book about ethical design practice, Lucienne Roberts says: 'Everyone has baggage that informs their thinking. So, just as politicians have to declare an interest, I thought it would be useful to include something of my history' (Roberts, 2006, p. 8). This struck me as a generous way to build trust and shared ground with a reader. So, in the interests of transparency, something of me:

Some macro level things first: By quirk of birth I'm middle class. By quirk of time I am middle aged. Politically, I'd call myself left of centre. I've always used my vote. It goes without saying (or shouldn't need saying but perhaps still does) that I am a feminist.

Home home: Lynton and Lynmouth on the North Devon coast in Exmoor National Park

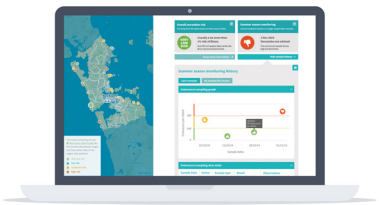
Zooming in a bit, I was born in 1976 in England and spent a chunk of my childhood in an idyllic rural area in the south west of England, where I lived with my parents and brother. It was 'small c' conservative, culturally and ethnically homogeneous. I went to the local comprehensive school, and did well enough without really trying.

I left home at 19 for university – a credible institution with a reputation for attracting private school educated Oxbridge rejects (of which I was neither). I earned a BSc in geography when environmental issues like climate change were becoming increasingly prominent. Studying geography I see in retrospect makes me consider processes and interconnectedness – a good generalist bedrock.

Post-university I went to work for the NGO WWF-UK, in a 'foot in the door' assistant role, from which I moved around, trying to be useful. One of my roles involved researching reputational risk associated with potential donors. I became more conscious about sustainability, and my sceptical perspective on 'corporate social responsibility' was cemented (and also too I lost my naïve perspective on NGOs' efficiency and efficacy). Most of my research was online and I developed strong views on effective web design. I went on to manage WWF's intranet. Internet-based communication and information management became my first real career.


My MDes thesis is online at makinggood.ac.nz

After moving to Aotearoa New Zealand in 2007, I started studying design at Massey University partly to scratch an itch I'd had since school, and partly as I'd begun to realise how necessary good design is to translate information. At first I shoehorned study in between information management work for Surf Life Saving New Zealand, but, as a good student I was offered a design job within the School of Design's then new studio Open Lab, alongside studying for a Masters degree. At Open Lab I was making my first forays into science communication as a designer, working on LAWA – Land Air Water Aotearoa (lawa.org.nz)– a website that made environmental data public – for the regional council sector. It's a project I'm proud of,



A screen from LAWA, showing drill-down to data and graphs.

A manifesto

We, the undersigned, are graphic designers, photographers and students who have been brought up in a world in which the techniques and apparatus of advertising have persistently been presented to us as the most lucrative, effective and desirable means of using our talents. We have been bombarded with publications devoted to this belief, applauding the work of those who have flogged their skill and imagination to sell such things as:

cat food, stomach powders, detergent, hair restorer, striped toothpaste, aftershave lotion, beforeshave lotion, slimming diets, fattening diets, deodorants, fizzy water, cigarettes, roll-ons, pull-ons and slip-ons.

By far the greatest time and effort of those working in the advertising industry are wasted on these trivial purposes, which contribute little or nothing to our national prosperity.

In common with an increasing number of the general public, we have reached a saturation point at which the high pitched scream of consumer selling is no more than sheer noise. We think that there are other things more worth using our skill and experience on. There are signs for streets and buildings, books and periodicals, catalogues, instructional manuals, industrial photography, educational aids, films, television features, scientific and industrial publications and all the other media through which we promote our trade, our education, our culture and our greater awareness of the world.

We do not advocate the abolition of high pressure consumer advertising: this is not feasible. Nor do we want to take any of the fun out of life. But we are proposing a reversal of priorities in favour of the more useful and more lasting forms of communication. We hope that our society will tire of gimmick merchants, status salesmen and hidden persuaders, and that the prior call on our skills will be for worthwhile purposes. With this in mind, we propose to share our experience and opinions, and to make them available to colleagues, students and others who may be interested.

Edward Wright
Geoffrey White
William Slack
Caroline Rawlence
Ian McLaren
Sam Lambert
Ivor Kamlish
Gerald Jones
Bernard Higton
Brian Grimbly
John Garner
Ken Garland
Anthony Froshaug
Robin Fior
Germano Facetti
Ivan Dodd
Harriet Crowder
Anthony Clift
Gerry Cinamon
Robert Chapman
Ray Carpenter
Ken Briggs

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The *First Things First* manifesto (Garland, 1964)

but had mixed feelings about in terms of the 'neutrality' of science when politics is involved. It was an interesting journey, and was probably what led me ultimately to *Science in Society*.

I'm no scientist, though I realise the science end of geography gives me some insight, and some degree of deference to the scientific method of a 'way of knowing'. My instinct is to 'trust' science and scientists. I want to know how to do things better in the post-truth quagmire (part of the reason I'm doing this research). I suppose this all makes me a default positivist? I'm not sure – the more I read, the more I wonder if I tend towards critical realism. I know the senses can deceive, I am interested in the big picture, or does the fact I think there's richness in our different perspectives make me an interpretivist,even?[1] From a design point of view, I'm a child of postmodernism – a lover of the hybrid, the playful, the 'messy vitality over obvious unity', to steal a term from Robert Venturi (Stierli, 2016). However, this exists under a crust of deference to the orderliness of 'International Style' Modernism, absorbed rote in design school, but also appealing to my pragmatic and process-orientated information manager's mind. Both are a predominantly aesthetic response rather than a philosophical one.

Where am I now? In a metamodern state of oscillating between? (Vermeulen & Akker, 2010). Not being a philosopher, or a sociologist, or an anthropologist means I lack the tools to define myself comfortably in such terms – finding out forms part of my current journey. In reality, I'm likely to pragmatically pick and mix – that's the designer in me.

Anyway, I digress. Let's jump back to 2014.

During my MDes I was interested in design manifestos as rallying cries for using design for 'good', the archetype of which is *First Things First* (Garland, 1964). The idea of design in pursuit of a better world still resonates. Now, too, I wonder about *good* design in terms of diversity, about who has privilege, about my privilege, and how I get to practice with the autonomy to choose what I do (unencumbered by family or finance pressures).

Then, as now, I am interested in the way design interacts with and helps communicate complex subjects, but I'm increasingly preoccupied with whose narrative I am foregrounding. I still worry that there is a tendency in 'design thinking' (especially in its business school manifestation) to neglect the micro in favour of the macro, and also, despite rhetoric of collaboration (codesign, multidisciplinary, interdisciplinary, transdisciplinary) I worry design education posits (tacitly, if not overtly) design as a panacea (and a 'white, western hero' one at that). I believe disciplinary boundaries should be porous, though I find myself drawing them while I try and work out the lie of the land (a generalist's constant low-level imposter syndrome). I'm still evolving my thoughts on what 'design' is, but I'm increasingly convinced it has to be synergy of process and 'thing' – not just the aesthetic object, not just a methodology or set of tools. This is an evolving conversation with myself, but mostly I like the design 'doing' – the thinking, making, and evolving.

1 As an aside here, I did a quiz at the end of Saunders, Lewis, & Thornhill's (2009) chapter on 'understanding research philosophies and approaches'. It's a book aimed at management students (not sure if that makes it less legitimate in my eyes) but I was surprised that it had me identifying least with positivism (-4), most with critical realism (+7), and level pegging for interpretivism, postmodernism and pragmatism (+5). It's not quite a Buzzfeed quiz, but a pinch of salt is no doubt required. Still, it's an interesting provocation about my own self-described identification and an external perspective on it.

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# The reflexive scientist: an approach to transforming public engagement

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**Abstract** Calls for greater public engagement with science (PES) are widespread, but there appears to be little agreement on the meaning and purpose of engagement across the various actors calling for it. This reflects a persistent gulf between PES scholars and scientists communicating with the public. We argue that direct engagement between PES scholars and scientist-communicators could, by facilitating greater reflexivity, lead to a step-change in the calibre and clarity of activities that are designed to support enhanced public engagement with science and technology. In this paper, we, as authors beginning from different perspectives, explore the potential of, and barriers to, a conversation between critical social scientists and members of the science community about public engagement. We demonstrate how and why the PES literature does not "speak for itself" to scientists but provides a starting point for conversation rather than a substitute for it. We then explore what reflexivity might mean for PES and argue for three important foci: political-economic context or politics of the field; institutional context; and personal assumptions. We then discuss barriers to, as well as strategies for, fostering such reflexivity, concluding that new models of authorship and publication are needed if this promise is to be fulfilled.

**Keywords** Science communication · Public engagement with science · Science outreach · Reflexivity · Reflexive scientist

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## Introduction

Calls for greater public engagement with science (PES) are widespread. There appears to be little agreement, however, on the meaning and purpose of engagement across the various actors calling for it. Within the social-science literature, a key recurring theme has been the need for a shift away from the "deficit model" of communication, in which it is assumed that public *support* for science (especially controversial science) will be achieved through better public *understanding of* science, and that this in turn can be achieved by addressing an apparent knowledge deficit with an injection of scientific information and explanations. In place of this model, many social scientists advocate more dialogic forms of public engagement with science (and scientists' engagement with the public). Such forms of engagement would, among other things, provide opportunities for public participants to identify non-technical factors relevant to evaluating a scientific project and/or to contribute otherwise neglected but valuable local and practitioner knowledge. These processes, sometimes characterised as the co-production of knowledge,[1] are argued to be particularly critical for addressing problems of environmental sustainability (Pohl et al. 2010; Bäckstrand 2003).

[1] The concept of co-production has at least two different meanings. What Jasanoff has termed 'the idiom of co-production' refers to the ways in which natural and social orders are 'produced together': '[w]hat we know about the world is intimately linked to our sense of what we can do about it, as well as to the felt legitimacy of specific actors, instruments and courses of action' (2004: p. 14). Research utilising this meaning of co-production looks to make explicit the generally obscured relationship between what we take to be the (given) natural world, on the one hand, and the social world of humanly created institutions and power relations, on the other. In transdisciplinary research, co-production refers to a deliberately interactive and collaborative process involving both academic (certified "expert") and non-academic actors, with their different types of knowledge (Gibbons et al. 1994; Mobjörk 2010; Pohl et al. 2010). We are using co-production in this latter sense.

The paper that started it: Salmon, R. A., Priestley, R. K., & Goven, J. (2017). The reflexive scientist: an approach to transforming public engagement. *Journal of Environmental Studies and Sciences*, 7(1), 53–68. https://doi.org/10.1007/s13412-015-0274-4

# Introduction

**This PhD project will examine** approaches to public engagement with science and technology (PEST) both at the level of individual practitioner (primarily the 'scientist communicator'[1]) and the organisation (primarily inter-institutional research networks[2]) in Aotearoa New Zealand. It will pose questions such as: is there a shared science communication vocabulary within the Aotearoa New Zealand scicomm[3] community? Are theoretical perspectives from social science disciplines reaching scientist-communicators? Are there consistent features of projects considered science communication exemplars? And, How do we classify and measure successful engagement outcomes? Design processes will be used to structure the project, design methods will be utilised to collect data, and design as an iterative, user centred activity will be used to explore ways to improve public engagement with science and technology. In essence, I am asking:

## How can design be used to improve public engagement with science and technology in Aotearoa New Zealand?

This proposal begins with some background information in this introduction, then examines some context, primarily the main threads of theory from science communication literature, perspectives on reflexivity, and the context of design as a pertinent disciplinary approach to use in this research. The research objectives explain what I intend to achieve, and the research plan outlines the 'nuts and bolts' of the proposed research project, in relation to the literature and context discussion.

## Project background

This PhD project is supported by a scholarship[4] that had its genesis in a 2017 paper, *The reflexive scientist: an approach to transforming public engagement*

1 'Scientist-communicator' is used in this proposal to mean scientists engaging in direct communication with non-expert audiences, in order to differentiate them from professional communicators. This was the approach adopted by Salmon, et al. (2017, p.54): 'In order to differentiate these activities from those carried out by people trained in PES, by institutional public-relations offices, or by the growing pool of professional engagement consultants, we refer to communication activities by scientists and science-trained communicators as 'science outreach', and to the people who initiate or carry out these activities as 'scientist-communicators'.

2 Inter-institutional research networks (or organisations) refers to entities such as Centres of Research Excellence (CoREs), where researchers come together from different institutions, or National Science Challenges, where projects are cross-disciplinary and mission-led.

3 Scicomm is a frequent abbreviation for science communication, and #scicomm is a well-used Twitter hashtag.

4 The scholarship is funded by Te Pūnaha Matatini (see over).

## About Te Pūnaha Matatini

Te Pūnaha Matatini, who funds my scholarship, is a Centre of Research Excellence (CoRE), which is an inter-institutional, interdisciplinary research network funded by the Tertiary Education Commission. The name means 'the meeting place of many faces'. Te Pūnaha Matatini's mission is to develop methods and tools for transforming complex data into knowledge in three strands: complexity, risk and uncertainty; complex economic and social systems; and complexity and the biosphere. They are fortunate to boast four winners of the Prime Minister's Science Communication prize amongst their affiliated researchers[1]. Te Pūnaha Matatini investigators currently invest significant time and resources into science communication but have limited capacity to evaluate, peer-review, and improve these activities, which is behind why as an organisation Te Pūnaha Matatini committed to improving science communication through this PhD project. CoREs, and the scientist-communicators within them, particularly Te Pūnaha Matatini, are going to form part of my focus.
www.tepunahamatatini.ac.nz


(Salmon, Priestley, & Goven, 2017). The paper highlights a 'persistent gulf between PES[5] scholars and scientists communicating with the public' and proposes that fostering and facilitating greater reflexivity[6] (through, for instance, understanding the personal assumptions or potential biases of the scientist-communicator, and the political and cultural contexts that they are operating within) could 'lead to a step-change in the calibre and clarity of activities that are designed to support enhanced public engagement with science and technology' (Salmon, et.al., 2017, p.53).

Reading this paper (acknowledging a certain law of the instrument, 'if all you have is a hammer, everything looks like a nail' tendency) it struck me that there was a tangible opportunity for design to offer a process and/or resources or tools to help 'foster reflexivity' in scientist-communicators, and it was on that basis that I was awarded and took up the scholarship.

Subsequent contextual review led me to frame the problem slightly differently, addressing not specifically (or wholly) scientist-communicator reflexive practice at the individual level, but at the way design could be used to bridge the 'persistent gulf' between science communication theory and practice that *The reflexive scientist* highlighted. This gap includes a lack of consistent use of terminology across disciplines (including terms such as engagement, outreach, and science communication), and the way planning for engagement tends to be done 'on a hunch' without reference to theory. In addition, though the theory within the field of science communication observes (and champions) a shift from one way to two way dialogue between scientists and the public (a move away from the 'deficit model' towards dialogue and participation), examples of genuine two way learning and coproduction, especially in the Aotearoa New Zealand context, are scant.

My literature observations were consistent with initial interviews and informal conversations with the scicomm community in Aotearoa New Zealand (which included scientists with an active hands-on public-facing programme of science-related activities, and high-profile scientists who now comment more generally on science and society issues). This was especially clear with regards to disparate uses of terminology, and in terms of the constraints on applying a reflexive lens when planning interaction with non-expert audiences. The Science and Technology Studies (STS) literature especially examines science-society intersections, and connecting scientist-communicators with some facets of this offers an opportunity to challenge them about the assumptions they hold, not only in regards to their own research, but about the role of science as the (assumed) preeminent 'way of knowing'.

1 Shaun Hendy (2012 winner) is currently Te Pūhana Matatini's Director, Siouxsie Wiles (2013) is a Principal Investigator (PI), Michelle Dickinson (2014) is an Associate Investigator (AI) and Rebecca Priestley (2016) is a PI.

5 Public Engagement with Science

6 Reflexivity is explored in more detail later, but in essence: 'Reflexivity is an attitude of attending systematically to the context of knowledge construction, especially to the effect of the researcher, at every step of the research process' (Cohen & Crabtree, 2006).

## Different perspectives

The role of considering different perspectives on a topic to aid reflexivity is well established. Cohen & Crabtree (2006) suggest 'this might lead to the development of different…equally valid, understandings of a particular situation under study'.

Social science (where I would situate most STS and PEST literature) sits at the intersection of the rational analysis of science and the interpretive enquiry of the humanities and arts. Design on the other hand lives *outside* science, and the humanities, being what Nigel Cross (1982, see figure 1) describes as a 'third culture', a particular way of looking at things that's different to the established 'two cultures'. I suggest this makes it a valuable 'different perspective'. This viewpoint might help build inter- (or even trans-) disciplinary learning, bridging pertinent knowledge from science and the humanities. (These 'disciplinarities' are extensively explored in various literatures, and are also encapsulated succinctly by Jensenius (2012) (figure 2), and summarised overleaf).

| | SCIENCE | HUMANITIES | DESIGN |
|---|---|---|---|
| PHENOMENON | the natural world | human experience | the man-made world |
| METHODS | controlled experiment, classification, analysis | analogy, metaphor, criticism, evaluation | modelling, pattern-formation, synthesis |
| VALUES | objectivity, rationality, neutrality, and a concern for 'truth' | subjectivity, imagination, commitment, and concern for 'justice' | practicality, ingenuity, empathy, and a concern for 'appropriateness' |

Figure 1: Nigel Cross describes a 'three cultures' view of human knowledge and ability as 'useful, if crude'. He characterises these 'cultures' based on the phenomenon, methods and values most clearly associated with each. Cross, N. (1982). Designerly ways of knowing. *Design Studies*, 3(4), 221–227

But what is 'design' in this context? Design is a multifaceted term, and far from a homogeneous, easily defined discipline. It can refer to both process and product, ranging from the abstract conception of something to the actual plans and processes required to achieve it. At one end of the spectrum, design can act as a 'translator' (what Matt Malpass (2016) calls design as an 'explanatory medium'), using design principles to make information easier to consume, understand, or orientate within. This would be where communication design usually lives in a commercial context. Participatory or codesign, with more agency given to users, audiences and

## Disciplinarities unpacked

I have suggested that design's 'different viewpoint might help build inter- (or even trans-) disciplinary learning'. These 'disciplinarities' are extensively explored in various literatures (and are neatly encapsulated visually by Jensenius (2012) (figure 2)), and the key differences can be summarised thus:

**Crossdisciplinary** is to view one discipline from the perspective of another.

**Multidisciplinary** draws on knowledge from different disciplines but stays within the boundaries of those fields. To use a food analogy (Nikolov(a) et al., n.d.), It's like a salad bowl, in which the ingredients remain intact and clearly distinguishable.

**Interdisciplinary** analyses, synthesises and harmonises links between disciplines into a coordinated and coherent whole. It's like a melting pot (such as a fondue or stew, in which the ingredients are only partially distinguishable)

**Transdisciplinary** integrates different disciplines and in so doing transcends each of their traditional boundaries. It's like a cake (in which the ingredients are no longer distinguishable, and the final product is of a different kind from the initial ingredients).

stakeholders, is perhaps more future focused (and shares many parallels with social science disciplines). At the other end of the spectrum, design can be deployed as an affective medium, which Malpass describes as 'challenging hegemonies and dominant ideologies in contexts of science and technology, social inequality, and unchallenged disciplinary norms... working in the 'ambivalent zone between emerging science and material culture...questioning potential applications and implications of scientific research being carried out' (Malpass, 2016, p.447). In this sense, it seems to pose similar questions to Science and Technology Studies (STS) and other disciplines relevant to science communication, which are, as Sarah Davies and Maja Horst point out, not 'simply about making difficult things more simple...it is something more than the exchange of scientific knowledge from those who know to those who do not. It is an integral part of society which has huge impacts on welfare, democracy and culture'(Davies & Horst, 2016, p.2).

I wonder, how can disparate disciplines or practices such as critical design and STS – both of which purport to provoke questions about the interplay of science and society – learn from or complement each other? How can looking at both science and social science (as repositories of 'content' (the 'thing' being communicated), and also as 'ways of knowing') be enhanced by approaching them from a different space? I am interested to explore the disciplinary intersections, locate overlapping practices, and produce research as a hybrid model drawing on approaches from design, Public Engagement with Science and Technology, and elsewhere.

The first part of the contextual review sets out to consider some of these terms, and how they have evolved with certain disciplines, in order to progress this research with some clarity about how they are used. This will provide a baseline when I explore how scientist-communicators use these terms in our Aotearoa New Zealand context, as the nomenclature may be employed with subtle differences. The second portion of the review outlines pertinent perspectives on the meaning and nature of reflexive practice, again to provide clarification on how I will employ the term during the research project. The other facet of the project, design approaches, is considered in the third part of the contextual review.

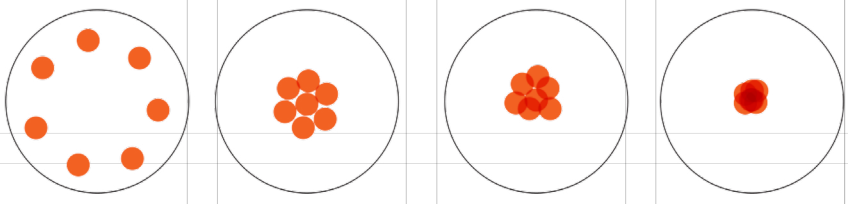


Figure 2: From left to right: crossdisciplinary, multidisciplinary, interdisciplinary, transdisiplinary (based on Jensenius (2012)

## Personal perspective

I have come to science communication as a field from the perspective of a practicing communication designer, where my focus has been on user-centering design for science communication to make it comprehensible to audiences without specific expertise. I come from a position of deferring to the scientific method as (what my undergraduate degree suggested was) the preeminent 'way of knowing', though I'm cognisant, having retrained as a designer, that there are other modes of discovery than falsifying a hypothesis. I also recognise that not everyone holds these values.

I admit to certain deficit-model assumptions (revealed to me through my own reflexive process) in terms of my hands-on scicomm experience. These were based largely on extrapolating from my own feelings around being under-equipped with knowledge about science, and wanting to know more. I defaulted to a mode in which I believed 'the public' (whoever they are) may be skeptical about, or merely ignorant of 'scientific facts', and, if only they had information, they would be seized with the urgency to change their behaviour (and therefore tacitly recognise that science and technology are 'good things'). I'm not alone though! Most of the early public understanding of science (PUS) field operated with the same assumptions. It is, however, as Dickinson (2005) points out, a model based on a 'highly flawed' hypothesis and, in fact, 'increased knowledge about modern science does not necessarily lead to greater enthusiasm for science-based technologies' (Dickinson, 2005).

> **'Now' seems a pertinent time to consider if science communication can be framed in a way that eschews the patriarchal position that exists within the default deficit mode**

'Now' seems a pertinent time to consider if science communication can be framed in a way that eschews the patriarchal position that exists within the default deficit mode, and also to a certain extent within design as a field (with its historical lauding of (mostly) male 'creative genius' designers). Exposure to feminist STS literature, and books like Nicola Gaston's Why Science Is Sexist (Gaston, 2015) have heightened my awareness of how pervasive – to the point it is unseen – a default patriarchal position is. In a similar way, I've become more aware that, as Linda Tuhiwai Smith says, research can be understood 'as a set of ideas, practices and privileges that were embedded in imperial expansionism' (Smith, 2012, p. 21). Understanding how mātauranga Māori could, or should, inform my research (and recognising that it is a fundamental part of why the Aotearoa New Zealand scicomm landscape is unique) needs due attention. I posit these things perhaps as more a part of my personal reflexive process than an aspect I will tackle head on, and acknowledge that I have work to do to consider ethnicity, class and colonialism (recognising my position of privilege as a white, middle class, educated, financially independent British woman).

I have also become attuned to the fact that my home discipline, design, is subject to the same, and other tensions. As a practitioner rooted in print and digital visual communication, I am increasingly feeling the limits of my conventional, somewhat commodified discipline-based design education, and subsequent commercial practice. As part of my own reflexive journey, I am starting to appreciate that design's roots – being fully integrated into the neoliberal model of capitalism (Dunne & Raby, 2013) – obscure an unencumbered perspective on the extant power structures that affect it. So just as design offers an alternative lens on science communication, the social sciences and humanities will perhaps offer me an alternative lens on design, and a way for my design practice to re-orientate and redefine away from 'the functionalist, rationalistic, and industrial traditions from which it emerged' (Escobar, 2018, p.xi). It's clear there is much to do, I believe a more reflexive communication mode within science communication might positively speed the tide of change.


Image adapted from Frederick Octavius Pickard-Cambridge (1860–1905), engraved by the Mintern Bros. firm, from a book edited by Henry Ogg Forbes [Public domain], via Wikimedia Commons

The potential entanglement of reflexivity, or the similie of the 'paralysed centipede who never walked again once he was asked to consider the difficulty in manipulating those legs'

(Ruby, 1982, p.2).

# Contextual review

**This review considers science communication** terminology through the evolution of perspectives on science-society relations, on the meaning and nature of reflexive practice for this research, and the next phase of my contextual review will focus on analysis of specific examples and case studies (of both public engagement strategy, deployment, and design in relation to these).

## Science communication terminology

There are some terms that have been used interchangeably in my proposal thus far, the key ones being science communication and public engagement with science. Though they are on occasion used as synonyms both in the literature and by the subjects of my initial interviews, they can be used with more specificity, and both are relevant in the context of this research project. In brief, science communication can be considered an umbrella term, and it can also encompass activities such as exhibition design, data visualisation and other practices which fall within the disciplines of design as a whole. Public engagement encompasses 'intentional, meaningful interactions that provide opportunities for mutual learning between scientists and members of the public' (Nisbet & Markowitz, 2015, p. 2), and is generally considered to be (or is aiming to be) a two-way dialogical process between science and society. The following section gives a contextual background to bring some degree of clarity before the next phase of this research project.

### What is science communication?

Science Communication could be categorised as a discipline, a practice, a professional activity, or all of the above. It has been described as 'an emerging discipline' (Trench & Bucchi, 2010) for the best part of a decade, with suggestion that 'further theoretical development is needed to support science communication's full emergence as a discipline' (Trench & Bucchi, 2010, p.1), and a tacit suggestion from the literature that disciplinary recognition is desirable.

But it is a broad church, meaning many things to many people. Ogawa (2013, p.4) suggests that the difficulty in defining science communication comes from the diversity of visions (frequently unexpressed or even not consciously recognised), that emerge from differing values within the science communication community, and individuals and organisations therein. Part of this is due to the multiplicity of interests: Bowater & Yeoman (2013, p.7) suggest science communication 'faces several challenges and one of the

biggest is its multidisciplinary nature; it can encompass communication studies, sociology, education, philosophy, history, political science, ethics and, of course, science itself'. Geography, STS, public relations, and from a practice base, various design disciplines may also overlap with the term.

As Davies & Horst (2016, p. 220) point out, 'Histories of science communication are also culturally located', and some of this is determined by the disciplinary location. In addition, geographically, most of the literature on defining science communication is located in a predominantly European context. Part of my process will be to document how terms are understood within Aotearoa New Zealand. If no shared vocabulary exists, this may need to be co-created to establish a shared understanding around the terminology.

Some definitions emphasise science communication as a process, for instance, Bryant (2003, p.360) calls it 'the processes by which the culture and knowledge of science are absorbed into the culture of the wider community.' Others emphasise the participants: Burns, O'Connor, & Stocklmayer (2003) highlight the 2000 *Science and the public: A review of science communication and public attitudes to science in Britain* definition, which states:

**The term 'science communication' encompasses communication between:**

- **groups within the scientific community, including those in academia and industry;**
- **the scientific community and the media;**
- **the scientific community and the public;**
- **the scientific community and the Government, or others in positions of power and/or authority;**
- **the scientific community and the Government, or others who influence policy;**
- **industry and the public;**
- **the media (including museums and science centres) and the public; and**
- **the Government and the public**

**(Office of Science and Technology & The Wellcome Trust, 2000, p. 12)**

This is similar in scope to Trench & Bucchi (2010) who also highlight multiple groups: '[science communication] concerns the communication between communities of scientists, interest groups, policy-makers and various publics. But, on further reflection, we have to consider whether science communication also includes communication between and within various scientific institutions and communities of scientists' (Trench & Bucchi, 2010, p.1). Though useful in demonstrating the breadth of potential participants (or not useful as it gives such broad scope), these descriptions are limited in that

***Science communication:* 'organised, explicit, and intended actions that aim to communicate scientific knowledge, methodology, processes or practices in settings where non-scientists are a recognized part of the audience'**

Horst, Davies & Irwin, 2017, p.884

they do not 'address the how or why' (Burns et al., 2003, p. 191).

Horst, Davies & Irwin (2017, p.884; see also Davies & Horst, 2016, p.4) define science communication as 'organised, explicit, and intended actions that aim to communicate scientific knowledge, methodology, processes or practices in settings where non-scientists are a recognized part of the audience'. An alternative definition from Mellor & Webster (2017, p. 1) states science communication is 'An umbrella term covering a wide variety of activities, including, professional communication by scientists; interactions between scientists and members of the public; the media representation of science; and the ways people use scientific knowledge in their own lives'.

Both are broad in terms of who does the communicating, but both also specify the public (or non-scientists) as the audience. How interested or invested the audience is has not been narrowed, and forms and formats are also undefined. For the purposes of this research, Horst, Davies & Irwin's definition is a good working description, but it is useful to recognise, as Mellor & Webster do, that science communication is an 'umbrella', with many disciplines having a vested interest, many possible activities encompassed, and other terms slotting underneath it.

## Relationship with other terms

Trench & Bucchi (2010, p.1) suggest Public Communication of Science and Technology (PCST) has commonly been used as a near-synonym for 'science communication'. Horst, Davies & Irwin (2017, p.882) suggest that PCST and STS are both fields that have an interest in science communication, but not all science communication lives within STS. Burns, et al. (2003, p.183) state that 'although people may use the term "science communication" as a synonym for public awareness of science (PAS), public understanding of science (PUS), scientific culture (SC), or scientific literacy (SL) — in fact many of these terms are often used interchangeably — it should not be confused with these important and closely related terms'. So, how are they related?

The evolution of terminology and models over time (see figure 3 and below) accounts for some of this, as one term overtakes another in popularity (such as public understanding of science (PUS) gaining prominence after the 1985 Bodmer Report (The Royal Society, 1985)), However, Burns, et al. (2003, p.190) also point to subtle variations in philosophy, approach or emphasis to some of these terms, which is pertinent when they are used concurrently in a contemporary context:

- **Public awareness of science aims to stimulate awareness of, and positive attitudes (or opinions) towards science.**
- **Public understanding of science, as the name suggests, focuses on understanding science: its content, processes, and social factors.**

— Scientific literacy is the ideal situation where people are aware of, interested and involved in, form opinions about, and seek to understand science.
— Scientific culture is a society-wide environment that appreciates and supports science and scientific literacy. It has important social and aesthetic (affective) aspects.

(Burns, O'Connor, & Stocklmayer, 2003, p.190)

Bryant (2003, p.361) also emphasises the relationship between terms, suggesting that ''understanding of science' and 'awareness of science' are two sides of the same coin', the first about education and a general public appreciation of scientific ideas. The second:

'Awareness' is concerned with encouraging the need to know in the individual or the community, with creating an affective change, that favours science, in that individual or community. It is hard to measure, but the best science communicators are able to engender and nurture that change. By so doing, they create a community that is as comfortable with its 'ownership' of science as it is comfortable with its 'ownership' of art.

(Bryant, 2003, p. 361)

***Public engagement:* '...intentional, meaningful interactions that provide opportunities for mutual learning between scientists and members of the public'**

Nisbet & Marcowitz (2015, p.2)

I include these definitions here because workshops with Te Pūnaha Matatini researchers in October 2018 suggested that 'scientific literacy' was their main communication aim. Bryant's 'awareness' encapsulates some of the sentiments that were expressed.

At a more granular (or perhaps practical) level, a study by Illingworth, Redfern, Millington, & Gray (2015) found that while 66% of participants agreed that their definitions of outreach, public engagement, and widening participation aligned with those of their colleagues, closer inspection of the open-ended questions found the respondents often differed in the use of the nomenclature. Further, as an example, the Illingworth study tried to define some of these terms based on the literature, and for outreach they ended up with: 'a one-way discourse, in which scientists communicate their research to the general public, with particular focus on school children and young people', which is in contrast to the way it's used elsewhere. In *The reflexive scientist*, Salmon et al. (2017) specifically state outreach is an ill-defined term, but pin it down to 'encompassing both one-way communication and two-way dialogue, or 'engagement' activities, between scientists and different publics'. And this is not the only contested term.

In a 2013 study looking at UK Beacons for Public Engagement (bodies funded by the Wellcome Trust and the UK version of the TEC, which aimed

to inspire a culture change in how universities engage with the public) Sarah Davies (2013, p.702) found that 'not only are there many different understandings and meanings of PEST co-existing simultaneously, but that each of these can also be accounted for through multiple narratives, genealogies, and personal histories'.

She goes on to say that it is somewhat disingenuous to speak of a single meaning for public engagement. Instead there are 'a thousand tiny origin myths, each tied to different places and people' (p.704). She wonders, as do I, if this is a UK phenomenon or a feature of PEST more generally? She says in the UK, politics and policy has tended to use the 'instrumentalist notion that dialogue will facilitate scientific progress' as an ideal that will 'unite British society in a progressive vision of the future', while Danish practices of 'consensusing' on science and technology are inextricably intertwined with shared understandings of national identity, where decisions are taken from a perspective of the common good.

If engagement is tied to notions of citizenship, I think it's important to be able to go forward with some clarity from the Aotearoa New Zealand perspective on this terminology, or, at least, accept it needs contextualising each time it's used.

## Science communication history

As many of the variations in terminology stem from changing trends, events and movements over time, the following section gives a brief background to key movements within the science communication field. This is limited to the period where science communication has been under scrutiny – the last three decades or so – though obviously people have been communicating about science throughout history. It is also notable that the documentation is rather UK-centric. I hope that part of what I can do in this project is to articulate some of the differences, or commonalities, between the UK and European experience (and further afield), and Aotearoa New Zealand's.

### Deficit towards dialogue: the big shift

From 'deficit to dialogue' is a shorthand term for science communication's evolution of ethos and terminology over the last three decades. Since 'the deficit model' was coined as a term, this transition has been the 'most solid thread of theoretical work in this field' (Trench & Bucchi, 2010, p.2) and has seen 'the gradual shift in policy discourse from keywords such as 'popularisation' and 'public understanding of science' to 'dialogue', 'engagement' and 'participation''(Bucchi & Trench, 2008, p.3).

The early 1980s can be characterised as an era where there was anxiety around the lack of public knowledge of basic scientific facts (the 'deficit' of knowledge). Following research by Durant et al. (1989), which revealed large

gaps[1] in what scientists considered basic facts, science communication was preoccupied with filling the knowledge gap so that the (ignorant) public developed a bedrock of science knowledge: 'the implication [being] that this stock of knowledge can be tested, in the same way as you test for literacy and numeracy' Bowater & Yeoman (2013, p.10).

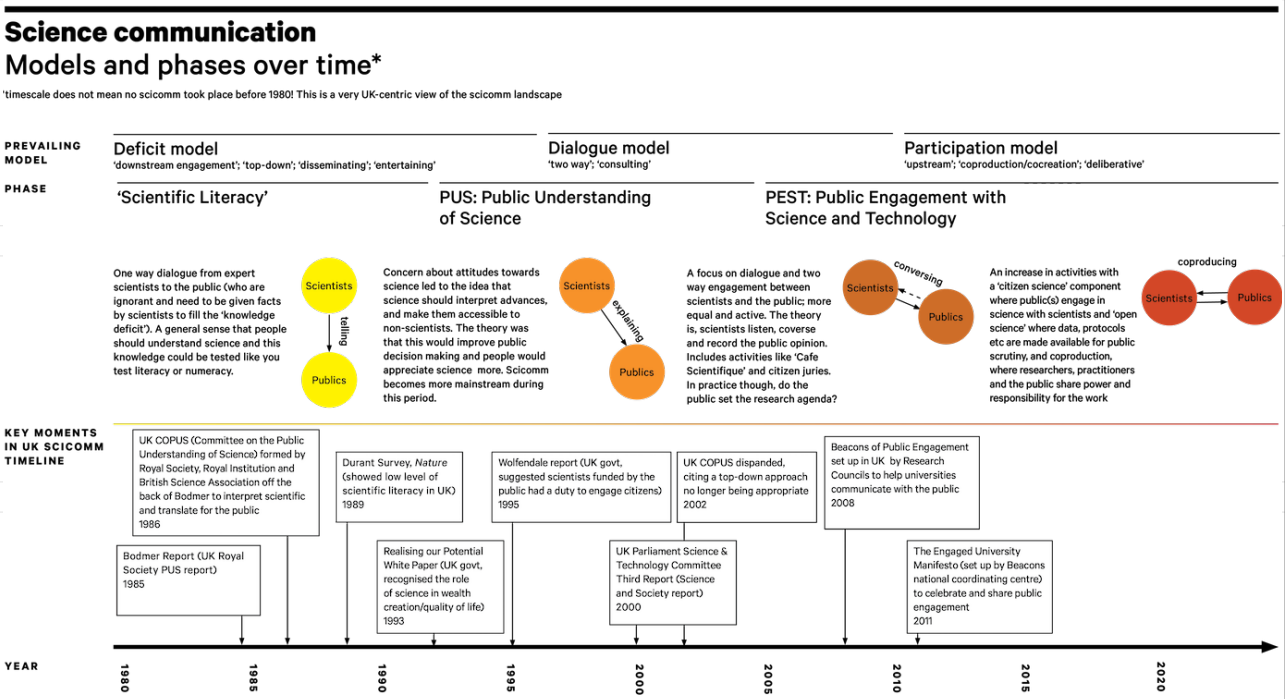



Figure 3: science communication models and phases over time, adapted from information in Bowater & Yeoman (2013), Davies (2013) and Bucchi & Trench (2014)

## Telling the 'ignorant public': Public Understanding of Science

A defining moment in science communication's story came with the UK Royal Society's T*he Public Understanding of Science* report in 1985. Commonly known as 'the Bodmer Report', it sought to 'show why it matters that all sections of the public should have some understanding of science and to stimulate action by scientists and others to improve this understanding' (The Royal Society, 1985, p.7), and suggested public understanding of science (PUS) was essential for the UK to make the most of its scientific potential (Stilgoe, 2009, p. 9).

As a result of the Bodmer Report, the tripartite Committee on the Public Understanding of Science (COPUS) was assembled in the UK by The Royal

1 Such gaps as only 34% of the British public and 46% of Americans knowing that the Earth goes around the Sun once a year. (Durant et al., 1989)

> **Within the deficit model there lies an inherent assumption about the superiority of science. ... one of the deficiencies ... was its failure to recognise that knowing facts does not translate to being able to usefully apply them**

Society, The Royal Institution and the British Association for the Advancement of Science. COPUS's aim was to make scientific advances accessible to non-experts (Bowater & Yeoman, 2013, p.12), and has been credited with a rise in the prominence of science journalism, science centres, festivals and popular science books (Stilgoe, 2009, p.9; Kerridge, 2015, p.72). Still though, PUS assumed a deficiency in the public but sufficiency in science (as holders of the knowledge). PUS adopted 'a one-way, top-down communication process, in which scientists—with all the required information — filled the knowledge vacuum in the scientifically illiterate general public as they saw fit' (Miller, 2001, p. 17).

Within the deficit model there lies an inherent assumption about the superiority of science. But for all the hand-wringing over the fact not many people knew antibiotics can't kill viruses, or the Earth goes around the Sun once a year, or AIDS being caused by a virus (Gross, 1994) (or similar facts that seem elemental to certain groups), one of the deficiencies of the deficit model was its failure to recognise that knowing facts does not translate to being able to usefully apply them: 'most of us are ignorant of most matters. What is deficient, rather, is to be ignorant where it matters to you, in particular situations.' (Gross, 1994, p.8).

Miller (2001, p.117) notes that at this time, 'alongside—but very separate from' the efforts of COPUS, there was a more reflective perspective on PUS germinating, drawing from other fields like sociology, history, and philosophy. Miller (2001) draws attention particularly to work by Brian Wynne and Alan Irwin, which showed that how science was interpreted by the public was highly contextual, with lay knowledge and social factors playing a key role. Interpretation was not, as had been assumed, an unambiguous and straightforward process, and furthermore, the public were not a homogeneous lump – there were 'consumers, activists, government [and other groups] all of whom had their own knowledge and stance on the issues' (Bowater & Yeoman, 2013, p.14). At the same time researchers such as Bruno Latour were examining the processes of science itself, noting that scientists had their own process of 'socialising' findings as they became laid down as 'reliable knowledge' through a process of 'social checks and balances' (Miller, 2001, p.117). This 'contextual approach' can be seen through a second foundational document of science communication, the House of Lords' 2000 *Science in Society* policy document (House of Lords, 2000).

### Talking to the diverse public: Public Engagement with Science and Technology

The House of Lords report not only set forth a new umbrella term: *Science in Society*, it also called strongly for a new era of dialogue and discussion between science and the public, and a rejection of deficit communication.

It highlighted that the public had an interest in science, but low trust, knocked by episodes such as the BSE epidemic and the 'rapid advance of areas such as biotechnology and IT' (House of Lords, 2000). It called for sweeping changes, and a post-PUS paradigm. Under the heading *A new mood for dialogue*, the report states:

**Despite all this activity and commitment, we have been told from several quarters that the expression "public understanding of science" may not be the most appropriate label. ... It is argued that the words imply a condescending assumption that any difficulties in the relationship between science and society are due entirely to ignorance and misunderstanding on the part of the public; and that, with enough public-understanding activity, the public can be brought to greater knowledge, whereupon all will be well.**

**(House of Lords (Select Committee appointed to consider Science and Technology), 2000)**

Public engagement with science and technology (PEST) then is characterised by the movement away from a one-way dissemination of facts and instead focuses on a two-way engagement between scientists and the public. Horst, Davies & Irwin (2017, p.886) list science cafés, consensus conferences, museum events and university open days as examples that have been categorised as 'public engagement'. They suggest that '(carefully mediated) opportunities for laypeople to question or interrogate the views and work of scientists' is the aim.

Another term that has been touched on briefly but is worth further noting here is public outreach, which is sometimes used as a synonym for engagement, notably in the UK (Bowater & Yeoman, 2013), but on occasion has a more specific meaning. In the UK, outreach is often used by universities to describe how they engage with schools (Bowater & Yeoman (2013, p.9) and The Royal Society and others use it to refer explicitly to science communication with school children (Illingworth, Redfern, Millington, & Gray, 2015).

Illingworth, et al. (2015) considered the literature and undertook a further survey that showed wide-ranging interpretation of the term outreach, but they summarise it as 'a one-way discourse, in which scientists communicate their research to the general public, with particular focus on schoolchildren and young people' (as opposed to engagement, which is 'a two-way dialogue, in which scientists converse with members of the general public in a mutually beneficial manner'). In *The reflexive scientist*, (Salmon, et al., 2017, p.54) the term is used to describe 'communication activities by scientists and

science-trained communicators'. They too draw attention to the 'ill-defined' nature of the term, and suggest that it 'should be seen to encompass both one-way 'communication' and two-way dialogue, or 'engagement' activities, between scientists and different publics' (whereas 'engagement' would suggest 'dialogical interaction').

The 'dialogue model' and resulting greater participation of the public in science is not without problems, nor has it wholly superseded top down 'speaking at the public' events (and, perhaps, there is room for a blend of approaches based on user (or audience) wants and needs). Davies (2009) notes that even within a purposefully designed 'dialogue event' at the Science Museum in London, the format contained both deficit and dialogue communication approaches. Bowater & Yeoman (2013, p. 17) document some additional shortcomings, such as the limited number of people that can participate, the lack of scope for participants to shape the agenda (and with that a power imbalance), and the fact that participants who are self-selecting tend to be unrepresentative of the public as a whole. Though the two way dialogue principle suggests that the public(s) have more agency through this model, this does not necessarily stretch to them helping to set the research agenda in advance of the developments taking place. Could a democratic public engagement approach actually set a research direction for an organisation, or even an individual researcher? At this fuzzy front end, especially with contentious issues for which social licence is not established (or is indeed resisted), how could a public engagement approach maintain an 'objective' stance? As Mellor & Webster (2017, p.2) state, 'Matters of judgment cannot be reduced to questions of science'. Is there an opportunity here for an overtly designed, reflexive approach?

That's not to say 'upstream' engagement – engaging public(s) in earlier stages of research and development rather than at later stages' (Parliamentary Office of Science and Technology, 2006) – has not taken place, but it has generally been 'in a vacuum – with no explicit link back to the research choices and innovation priorities of scientists or industry, or to the decisions of policy-makers' (Wilsdon & Willis, 2004). Meaningful engagement could inform policy, direct funding priorities and 'open up questions, provoke debate, expose differences and interrogate assumptions' (Wilsdon & Willis, 2004, p.40). But, as Wilsdon & Willis (2004) point out (highlighting work by Brian Wynne), if the questions are framed by the 'experts' this is simply the deficit model in new clothes. This suggests a need for a hierarchy or matrix of science communication that not only takes into account who is talking to whom, but also at what stage it is occurring, how contentious or controversial the issue is, and how much impact the public(s) role will have on determining what happens subsequently (figure 4).

There is an assumption that engagement is (or should be) carried out in 'a dialogue model of communication [with a] public who should be listened to, who had something meaningful to input into scientific policy-making' (Lock, 2013). If an engagement activity is two way (with a mechanism for conversation), but has a purpose of sharing facts or skills, is it truly two way? Is a one way delivery mode (for instance a presentation with no feedback mechanism) that provokes thinking about complex issues in a new way less legitimate because of its 'deficit model' status? In what ways can a science-communicator or organisation incorporate these considerations into a reflexive approach to science communication? Could overt recognition of the intent of a communication and the potential role of the public help the researcher be more reflexive, transparent, and user (or audience)-centric?

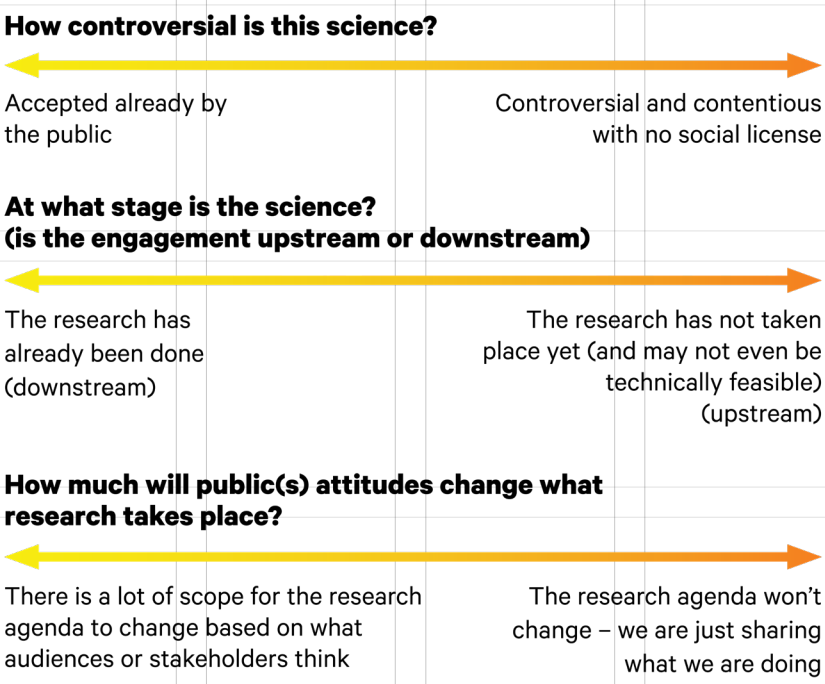



Figure 4: Public(s) and their relationship with the science in question – aspects that may help user-centre or engender transparency in engagement

## The Aotearoa New Zealand context

The above review demonstrates that key terms in this field are in flux, and understood or used in different ways across localities and disciplines. There is little research on the way the terms science communication, engagement and outreach are understood or used in Aotearoa New Zealand, likely due to our 'fairly limited science communication landscape, relative to other countries' (Salmon & Priestley, 2015, p.101).

Though in what is perhaps a marker of science communication's perceived value in Aotearoa New Zealand, there is increasing recognition

### About NSCs

The National Science Challenges are cross-disciplinary, mission-led programmes designed to take a strategic approach to the Government's science investment by targeting a series of goals, which, if achieved, would have major and enduring benefits for New Zealand. They require collaboration between researchers from universities and other academic institutions, Crown research institutes, businesses and non-government organisations to achieve their objectives.
https://www.mbie.govt.nz/science-and-technology/science-and-innovation/funding-information-and-opportunities/investment-funds/national-science-challenges/

National SCIENCE Challenges

### Abour CoRES

The Aotearoa New Zealand Centres of Research Excellence (CoREs) Fund was established in 2001 to encourage the development of quality tertiary education-based research that is collaborative, strategically focused and creates significant knowledge transfer activities. Funded by the Tertiary Education Commission, CoREs are inter-institutional research networks, with researchers working together on commonly agreed work programmes.
https://www.tec.govt.nz/funding/funding-and-performance/funding/fund-finder/centres-of-research-excellence/

Tertiary Education Commission
Te Amorangi Mātauranga Matua
Centres of Research Excellence

for 'top' science communicators through prizes such as the Prime Minister's Science Communication Prize, the New Zealand Association of Scientists (NZAS) annual Science Communicator Award (now called the Cranwell Medal) and the Royal Society of New Zealand Callaghan Medal all recognising public-facing communication. Though increasing profile for the field is positive, Salmon & Preistley (2015, p.103) point out that 'in rewarding only 'superstar scientists' we are missing the opportunity to celebrate and reward a range of different engagement practices, such as long-term and collaborative programmes, programmes that have been shown to succeed in meeting a specific engagement goal, or participatory programmes focused on co-production of knowledge'.

A 2012 report for the then Ministry for Science and Innovation (Winstanley & Hepi, 2012) showed that in Aotearoa New Zealand, there was a general view amongst CRI[2] and university scientists that 'non-peer communication [is] inherent in 'being a scientist' (p.xi), and many scientists engage with these audience in fora such as science festivals, dialogue events, public lectures, school visits and media interviews (Winstanley & Hepi, 2012), demonstrating what Salmon & Priestley (2015) call their 'commitment to 'public outreach''.

It is also worth noting that Winstanley & Hepi did identify that 'scientists participating in their focus groups provided numerous examples of holding a public deficit view', and that 'very few scientists mentioned the purpose of science communication as able to improve or contribute to decision-making by those with whom they were communicating', suggesting a lack of awareness of the PEST literature and its advocating for two-way dialogue and participation.

The situation may well have evolved, and in recent years, the government has established initiatives that call for greater public engagement in science: the National Science Challenges[3] (NSCs) (established 2013) and the Centres of Research Excellence[4] (established in 2001 with a further four CoREs added in 2015). However, there is little clarification on terminology in these programmes. In the Request for Proposals (RFP) for NSCs (Ministry of Business, Innovation and Employment, 2013), it is explicitly stated that 'Public outreach, communication, public engagement, and education activities are an important and required component of NSC activity and NSC funding can be used for such activities', yet these activities are not further defined. 'Public engagement' is listed in the CoRE's Performance and Management framework as a performance theme, though there is no standardised performance reporting framework (Tertiary Education Commission, 2015).

2 Crown research institutes
3 National Science Challenges (see left)
4 Centres of Research Excellence (see left)

Vaguely used terms are not, in and of themselves a problem, though it clearly makes assessing impact or measuring success difficult. This could be overcome with contextual clarification within individual projects, but assuming there is a consistent sector-wide understanding is not supported by the literature, or within my initial interviews and informal conversations. Would building greater connection between scientist-communicators and PEST literature help both strengthen individuals' capacity to eschew 'knowledge deficit' views of their potential audiences, and to help them reflect on the positioning of their research in society, and in relation to different publics?

## Reflexive practice

Reflexivity has been posited as a tool to examine the effectiveness of public engagement with science activities (Bauer & Jensen, 2011; Irwin, 2014) and it has been suggested that 'public dialogue and upstream engagement on science and technology is undergoing its own reflexive turn' (Chilvers, 2012, p. 284).

Many authors, including Cunliffe (2004) and Salmon, et al. (2017) draw attention to the variety of disciplines who utilise concepts of reflexivity, including sociology, anthropology, psychology, the natural sciences, economics and management studies, as well as STS and PUS/PEST. Lynch (2000, p.27) offers a comprehensive 'inventory of reflexivities' from a sociological perspective, underlining the 'confusing array of versions of reflexivity' from within that field. Ashmore (1989, pp. 30–31) concludes 'that uses of 'reflexive' and 'reflexivity' in social science discourse tend to be subject to unsystematic variation'. Other disciplines such as economics (see Beinhocker, 2013) and organisation and management studies (see Cunliffe 2004, 2016; Hibbert, MacIntosh, & Coupland, 2010) have their own particular angles. So what, in the context of the scientist-communicator, do we mean by reflexivity?

### What is reflexivity?

In a definition from the PUS field, (Wynne, 1993, p.324) suggests reflexivity is 'the process of identifying, and critically examining (and thus rendering open to change), the basic, preanalytic assumptions that frame knowledge-commitments'. This is similar to Cunliffe (2004), who defined critically reflexive practice as embracing 'subjective understandings of reality as a basis for thinking more critically about the impact of our assumptions, values, and actions on others' (p.407). She has since evolved her definition to 'Questioning what we, and others, might be taking for granted—what is being said and not said—and examining the impact this has or might have'

***Reflexivity*: 'examining our own assumptions, decisions, actions, interactions, and the assumptions underpinning organizational policies and practices and the intended and potentially unintended impact'.**

Cunliffe, 2016, p.741

(Cunliffe, 2016, p.741). She expands to explain: 'This means examining our own assumptions, decisions, actions, interactions, and the assumptions underpinning organizational policies and practices and the intended and potentially unintended impact'. She further suggests that reflexivity works at two levels: 'being self-reflexive about our own beliefs, values, and so on, and the nature of our relationships with others, what we say, and how we treat them', and being critically reflexive about 'organizational practices, policies, social structures, and knowledge bases' (Cunliffe, 2016, p.741).

Salmon, et al. (2017, p. 58) summarise in a similar vein, though with more emphasis drawing out the reflexive process with action:

> **Generally speaking, reflexivity requires self-questioning, in particular a willingness and ability to question one's own assumptions, how they relate to societal power structures, and how they shape one's actions. More specifically, here, we use reflexivity to mean a theoretically informed capacity to critically analyse one's underlying assumptions, expectations, and positioning in relation to one's involvement in outreach. It is not simply an internal thought process, but rather a type of thinking tied to action.**
>
> **(Salmon, et al., 2017, p.58)**

This action-centric approach to reflexivity resonates with the literature that as a designer, I was most aware of: Donald Schön's *Reflective Practitioner* (Schön, 1982) and his approach of reflection-on-action (post) or reflection-in-action (during practice). Kerridge (2015, p. 22) characterises this as 'design[ing] as a conversation with a situation'. Schön's approach of research through the context of practice gives a methodological legitimacy to the design process, and for Kerridge, offers a way to detach design from the 'recursive specification of its objects' (Kerridge, 2015, p.22). This allows the consideration that 'design could include formats of engagement, the interactions with the institutions that support that engagement, and an account of the people who are engaged' (Kerridge, 2015, p.23).

Another element that has value when considering reflexive practice for science communication is where it fits within a contained project (though, reflexivity can (should?) act as a mode of practice on a continual basis for an individual researcher). In a case study on embedding reflexivity within experiential qualitative psychology, Shaw (2010, p.233) demonstrates, through a frank disclosure of an instance where she was caught off guard when interviewing a vulnerable subject, that there is work to do for researchers in advance of and during data collection. She states: 'We need to reveal our presuppositions in order to not be surprised by them (or what

they do) anymore … By engaging reflexively with these fore-understandings and making them explicit in advance of data gathering, we are able to work actively with them in a research encounter' (Shaw, 2010, p.233). This action of 'making [assumptions, biases etcetera] explicit' is a form of Salmon, Priestley, & Goven's 'thinking tied to action' (2017, p.57), especially if utilised both pre and post research (or engagement intervention), in an iterative learning cycle. These approaches also have many parallels with the process of 'empathy-building' within design thinking methodologies, and I foresee a drawing together of these modes as a hybrid process for this project.

## Reflection to reflexivity

In terms of thinking practically about what 'counts' as reflexivity, making the distinction between reflection and reflexivity is something I found useful. The analogy of 'looking in a mirror' versus 'looking at yourself looking in a mirror' can clarify the number of 'loops' that are being utilised. Hibbert, et al. (2010, pp.1-2) describe this as like 'a mirror image which affords the opportunity to engage in an observation or examination of our ways of doing. When we experience reflection we become observers of our own practice', and at the deeper level, reflexivity suggests:

**…a complexification of thinking and experience, or thinking about experience. …we regard reflexivity as a process of exposing or questioning our ways of doing. As such reflexivity is related to reflection yet is qualitatively different from it. Finally, recursion suggests a return, a process of defining something in terms of itself and thus a returning to our ways of doing. Hence, reflexivity is more than reflection. What is implied is that, through questioning the bases of our interpretations, reflexivity necessarily brings about change in the process of reflection – it is thereby recursive.**

**(Hibbert et al., 2010, pp.1–2)**

So in this form, the process of reflection to reflexivity can in itself be cyclical, or (in a process similar to design), iterative.

When getting to grips with facets of reflexivity, I found the idea of a spectrum of reflection to reflexivity to be a useful framework. Woolgar's (1988) framing of a continuum offers a useful device to appreciate the diversity of positions on reflection to reflexivity, especially how operating within a positivist or interpretivist paradigm (Shaw, 2010) will have a bearing on how reflexivity is employed.

| Reflection | 'Radical constitutive reflexivity' |
|---|---|
| 'Benign introspection'<br>General thoughts concerned with process verification<br>Thinking about what we are doing<br>Positivist distinction between object and representation<br>Aim to present 'accurate' representation of participants' acccounts<br>Helping to confirm the scientific product is an accurate representation | Reality constructed contemporaneously (postmodern stance)<br>No one perspective has more value than another<br>'Explicit evaluation of self'<br>Look for similarities between our actions as researchers and those we are studying |

Figure 5: Woolgar's 'continuum of reflexivity', developed from descriptions in Shaw (2010)

On one pole of the continuum, we have the esoteric, ironic dizzying twists and all-consuming circularity of 'radical reflexivity' à la Woolgar (1988), Ashmore (1989) and others in SSK/STS[5], which can make for entertaining reading (hyper-reflexive, ironic, blending fiction and non-fiction into a novel literary form), though the approach has been heavily critiqued (Sharrock & Anderson, 2015[6]; Latour, 1988[7]). At the other, we have a more straightforward reflection, that might have 'the intent of reflexivity, but stays within the accepted boundaries of thought for addressing a particular issue or process' (Hibbert, et al., 2010, pp.9). Shaw (2010) gives a useful articulation of Woolgar's 'continuum of reflexivity' (Woolgar, 1988) (see also figure 5 above):

5 Sharrock & Anderson (2015, p.1) consider SSK (Sociology of Scientific Knowledge) as having been subsumed or replaced by STS (Science and Technology Studies)

6 In a critique of autoethnography, in which Sharrock & Anderson (2015) discuss the late 1980s 'radical reflexivity' of Woolgar, Ashmore et al. as the 'inspiration for some of the dottiest ideas to have emerged in sociology for a long time' (p.1), they describe autoethnography adopting from 'radical reflexivity': 'license to both challenge conventional forms of sociological reportage...and to promote the recounting of the sociologist's personal experience, not as a resource for sociological reflection, but as sociological reflection itself.'

7 Latour's critique of Ashmore and Woolgar's approach is encapsulated in this passage: 'By making social explanations of the behaviour of natural scientists they make it impossible for their own explanations to be seriously believed by anyone. Their arguments in feeding back on themselves nullify their own claims. They are in effect self-contradictory, or at least entangled in a sort of aporia similar to the famous 'all Cretans are liars', aporia from which they cannot escape except by indefinite navelgazing, dangerous solipsism, insanity and probably death'. (Latour, 1988, p.155)

**At one extreme of Woolgar's continuum we have benign introspection, or reflection, which maintains a positivist distinction between object and representation and thereby aims to present an "accurate" representation of participants' accounts. At the other extreme, we have radical constitutive reflexivity, which takes the postmodern stance that reality is constructed contemporaneously and no account (whether the researcher's or the participant's) can be valued over another.**

**Shaw (2010, p.234)**

Woolgar sought to use reflexivity to scrutinise STS outputs using the tools of their own analysis (and his peer Ashmore went further by seeking to 'debunk' them), and though their approach is perhaps too self-referential (or 'introverted', as Wynne (1993, p.324) puts it), and their unorthodox literary outputs too esoteric to be a practical everyday tool for scientist-communicators to employ, it is still useful to site one's position on the continuum when determining the values and assumptions one holds.

Some of the criticisms of postmodern radical reflexivity hinge on the fact that it can lead to a kind of 'self absorption…in which boundaries between subject and object disappear, one becomes the other… a process that denies the possibility of social research' (Davies, 2008, p. 4). Jay Ruby and Barbara Myerhoff use a simile to articulate this entanglement: a 'paralysed centipede who never walked again once he was asked to consider the difficulty in manipulating those legs' (Ruby, 1982, p.2). Charlotte Davies suggests rejecting the 'extreme pessimism' of the postmodern critique of reflexivity while adopting some elements, such as the incorporation of different standpoints (Davies, 2008, p.5). She posits a critical realist position, where reflexive ethnographic research 'can be based on a realist ontology, which assumes a social reality independent of our knowledge of it' (p.6); developing explanations of social reality 'by developing explanation of social forms…as well as critically examining the conceptualisations used in these explanations' (Davies, 2008, p. 6).

She further suggests that a critical realist social research recognises and is tied to 'questions of meaning and interpretation due to the self-conscious nature of its subject matter (p.6). She states that (unlike the natural sciences), social research involves a 'double hermeneutic' that is 'answerable to both the scientific community and those being studied', and, in an approach that has relevance to science communication, this enables 'interpretations and influences to pass in both directions, and final products thus may take on various forms and be addressed to different audiences'. I can envisage that in an extrapolation of this, scientist-communicators are answerable to the scientific community, the subject of their research, and the audiences with

whom they engage. A critical realism informed design process may help enable this.

## Bridging the practice-theory gap

Salmon, et al. (2017) point to a lack of incentive (and barriers), to scientist-communicators seeking to engage with the broader PEST literature. The result is scientist-communicator outreach that lacks 'higher level integration... either by the scientists themselves or by social scientists directed at scientists' (2017, p.62). Part of the result is activity informed largely by intuition, or by an institution's agenda (a perspective also highlighted by Harris (2018) (see figure 6)).

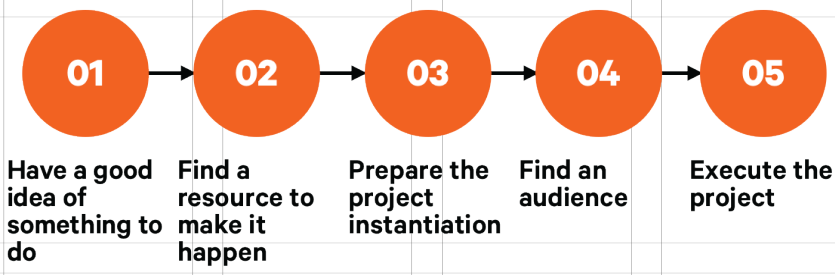



Figure 6: a model of scientist-communicator research (Harris, 2018)

Salmon et al. (2017) interviewed several scientist-communicators, all ostensibly within the same field, they identified three pertinent 'foci of reflection': political-economic context; institutional context; and personal assumptions (2017, p.59). The process of interviewing, and making 'visible' personal perspectives on these contexts was in itself a reflexive activity. In a similar vein, a target of this research is to facilitate opportunities to reflexively contextualise participants' engagement activities. Salmon, et al. propose that a first step toward fostering reflexivity is to 'stimulate questions' about the field the scientist-communicator operates in, the ways political-economic constraints may influence engagement or outreach, and also if the scientist-communicator is able to be open about any influences, or constraints (2017, p.59). If a facilitator in this process is from a different discipline (social science, as Salmon, et al. (2017) suggest, or design in my case), perhaps this offers a starting point. To see how the 'foundational assumptions and ideological baggage of one's own field of research are seen through the eyes of practitioners from other disciplines' (Wilson, Hawkins, & Sim, 2015, p. 154) could help reveal 'commonalities', or shine a light on fundamental differences that were previously invisible.

**even before you get to the myriad types of design, it's already complicated:**

noun, indicating a general concept of a field as a whole

verb, indicating action or process

noun, meaning a concept or proposal

noun, indicating a finished product

# *Design is to design a design to produce a design.*

Adapted from Heskett, J. (2005). *Design : A Very Short Introduction*. Oxford: Oxford University Press, pp.3-4.

# Design

**Design, as described in** the introduction, is far from a homogeneous, easily defined area. This section gives some context to how it might be applied in this project. At the most general level, it can refer to both process and product, 'ranging from the abstract conception of something to the actual plans and processes required to achieve it' (Giacomin, 2014, p. 607). Design is also ubiquitous: 'we all live within a design cluster, that is, immersed in designs of all kinds, which means that design becomes 'a category beyond categories'' (Lunenfeld, 2003 in Escobar, 2018, p.10). In addition, design has changed over time, becoming increasingly professionalised, and finding application not only as a communication medium, but as a problem solving mechanism within policy and business environments, and as a provocateur, speculating about future scenarios.

## A research through design approach

Design as a disciplinary vehicle for this research, and my identification as a designer, confer certain opportunities. Though I have a background that includes a geography degree, I do not identify as a scientist or a social scientist. As such, I can knowingly utilise my 'outsider' status to explore science communication from this alternative perspective. Secondly, I seek to approach both the research at a macro (top-level structural) level, and interventions (or case studies) within it through a design process lens which places emphasis on identifying, understanding, designing for and testing with 'users' (or specific stakeholders or publics). Thirdly, design as a discipline has had multifaceted relationships with science and science communication (or with society more generally), and I see opportunities for utilising different modes for different parts of the project. At one end of the spectrum (see figure 7), design can act as a 'translator' (design as an 'explanatory medium' (Malpass, 2016)), using design principles to make information easier to consume, understand, or orientate within. At the other, design can be deployed as an affective medium, 'challenging hegemonies and dominant ideologies in contexts of science and technology, social inequality, and unchallenged disciplinary norms' (Malpass, 2017, p.6), working in the 'ambivalent zone between emerging science and material culture… questioning potential applications and implications of scientific research being carried out' (Malpass, 2016, p.447). In between, participatory design or codesign places emphasis on involving stakeholders directly in the design process of the products, services or technologies they use (an approach used in healthcare and increasingly public service design, and crossing over considerably with some social science disciplines).

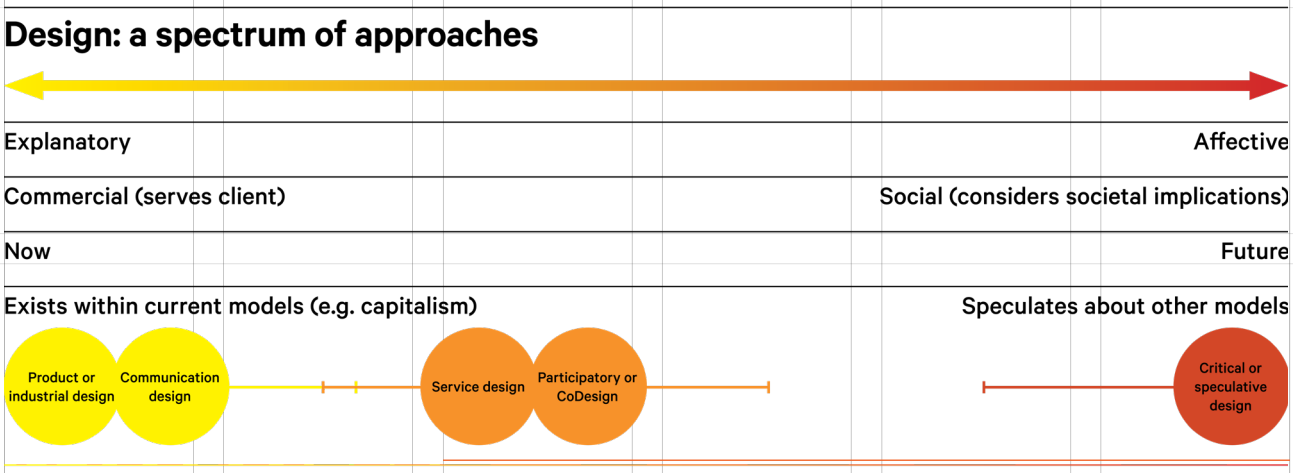



Figure 7: a spectrum of design, from explanatory to affective, informed by Malpass (2016) and Dunne & Raby (2009)

A commonality across all design is process. Not necessarily the same for each instance, and certainly not as uniform as neat diagrams from business schools would have you believe. But there is always a catalyst (often a client brief, sometimes a problem or need or want), and a series of analysis, synthesis, appraisal (rinse and repeat) before some kind of outcome is produced. This process applies if the project sits within a more conventional object or service orientated mode offering solutions to identifiable problems, or in a speculative, provocative project. There are two approaches that I seek to position my research in relation to, and together they will be combined to cover both aspects of design. These are design thinking and critical design.

## The rise of design thinking

The recent history of design has seen a reorientation away from its strong association with the object and from the 'designer as expert' towards a 'conception of design as user centered, situated, interactive, and participatory, focused significantly on the production of human experience and life itself' (Escobar, 2014, p.48). A focus on human-centred design and participatory design or codesign (both intrinsically linked with 'design thinking' approaches) have shifted the focus of design from product to experience. Many of these ideas are not new, though recent history (especially the last decade) has seen them 'packaged' and commodified, most notably by design firm IDEO, and also through Stanford University's D.School, both of which have been instrumental in expanding the interest of design process into applications beyond their traditional remit, for instance business process contexts, and working on 'wicked' problems.

So what is design thinking? Put simply, it describes a user-centred,

experiment-orientated[1] iterative cycle of design. It places emphasis on building empathy with users, and has a mindset of rapid prototyping to generate momentum and maximise opportunities to test and refine. It has been described as an 'analytic and creative process that engages a person in opportunities to experiment, create and prototype models, gather feedback, and redesign' (Razzouk & Shute, 2012, p.330).

Tim Brown of IDEO articulates design thinking as the design community being challenged to 'think beyond both the omnipotent designer and the obsession with products, objects, and things' (Bjögvinsson, Pelle, & Hillgren, 2012, p.101). His tenets of design thinking include:

1. that designers should be more involved in the big picture of socially innovative design, beyond the economic bottom line;
2. that design is a collaborative effort where the design process is spread among diverse participating stakeholders and competences;
3. and that ideas have to be envisioned, "prototyped," and explored in a hands-on way, tried out early in the design process in ways characterized by human-centeredness, empathy, and optimism.

(Bjögvinsson, et al., 2012, p.101)

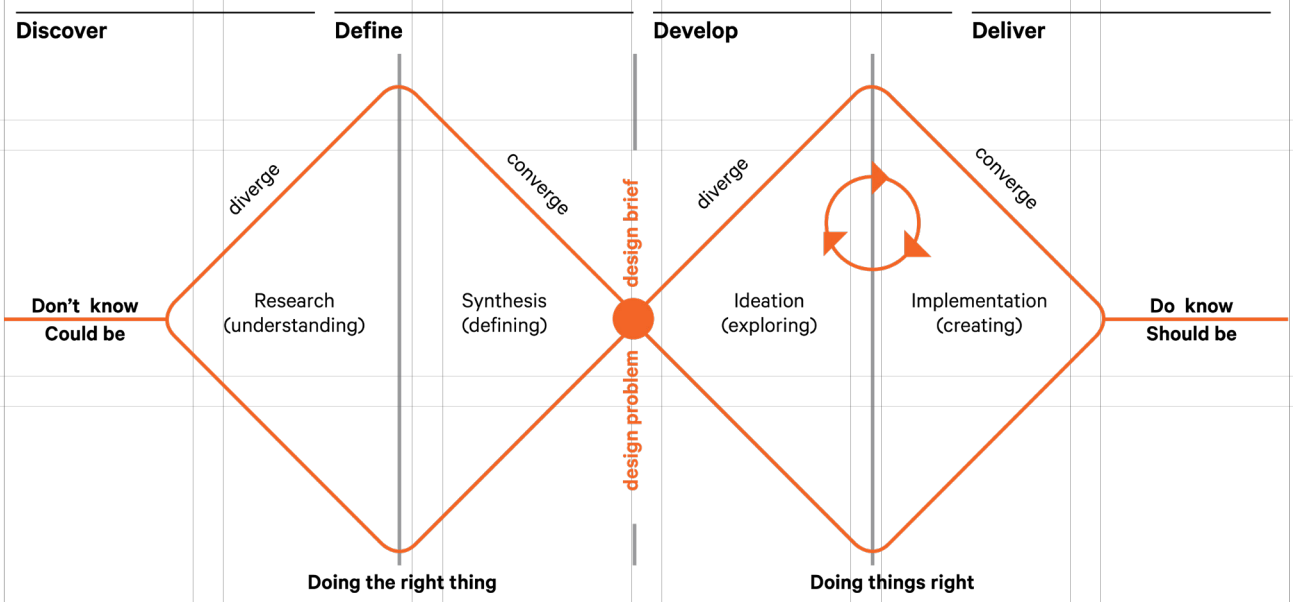



Figure 8: Based on the 'Double Diamond' by the Design Council (UK) https://www.designcouncil.org.uk/news-opinion/design-process-what-double-diamond (Design Council (UK), n.d.)

1 Disambiguation may be useful here: 'experiment' in the sense of 'try out new ideas or methods' or 'a course of action tentatively adopted without being sure of the outcome' to be evolved based on observation – *not* in the scienfic method, hypothesis-testing sense.

Figure 8 (previous page) shows a standard design process model based on the UK Design Council's 'Double Diamond'. The Double Diamond explains the design process as two halves, the first about understanding the issue, the second about exploring the solutions. The idea being, working through the first diamond prevents you solving the wrong problem in the second. This is one of many diagrammatical articulations of how design can work in a structured way towards solutions (the Stanford D.School's method uses the terms *Empathise, Define, Ideate, Prototype, Test*). It entails entering the process without a predetermined idea of the outcome or solution, and requires stages of broad divergent thinking, and synthesis. This can allow for iterative approaches to solution-building and hands-on testing. This process can apply if the project sits within a more conventional object or service orientated mode offering solutions to identifiable problems, or in a speculative, provocative project, or one dealing with wicked problems.

Design thinking processes are human centred – they focus on people and understanding their wants and needs – be these customers, users, employees, or we might call them publics. This is because eventually, the user is the one who decides whether a product or a service or offering will be successful. This approach requires not going in with a preconceived idea of the solution, and it involves an iterative cycle. Methods within this process, like interviews and observations may share some commonalities with social sciences, sitting within this wider framework. I intend on applying this process to both the (macro) overarching research project level, and (micro) within individual intervention designs.

Despite the focus on people, collaboration and problem solving, design thinking can be seen as an approach that remains largely uncritical of the political and power contexts in which it operates, and it is still focused on servicing the needs of clients and capitalism (especially the US variant (Escobar, 2018, p.48)). As such, a reflexive approach integrated into a design thinking process offers an opportunity to consider the visibility of these power structures, and the possibility to reorientate away from them, or at least make them overtly visible. I will also use critical design (see page 39) as a counterbalance to design thinking, partly to help me maintain a 'reflexive incredulity' – a way to ensure that I'm considering bigger issues of science and society interactions as well as problem-solving at a zoomed in scale.

Before I go on to consider critical design as an alternative or complementary mode, I will briefly give some context to human-centred design and participatory design or codesign as approaches that are extant within design thinking:

### Human-centred design

Human-centred and user-centred design (HCD and UCD) are very closely related, and are in fact synonymous in many cases (figure 9). User-centred

design has its roots in ergonomics and human computer interaction (HCI), and is closely tied to digital user experience (UX) contexts where the person performing a task is known and the process therefore tends to focus on optimising the characteristics of the product, system or service based on preconceived plans. In the context of software or hardware, the person using the product may also consider *themselves* to be a user, whereas in other cases, for instance, physical objects such as door knobs or light switches, 'user' feels a little clinical and detached. Human-centred design is broader, in that in many contexts, a design outcome may have multiple different types of user (or customer, or stakeholder, etcetera), so focussing on one may ignore the needs of others (Bowen, 2009, p. 27).

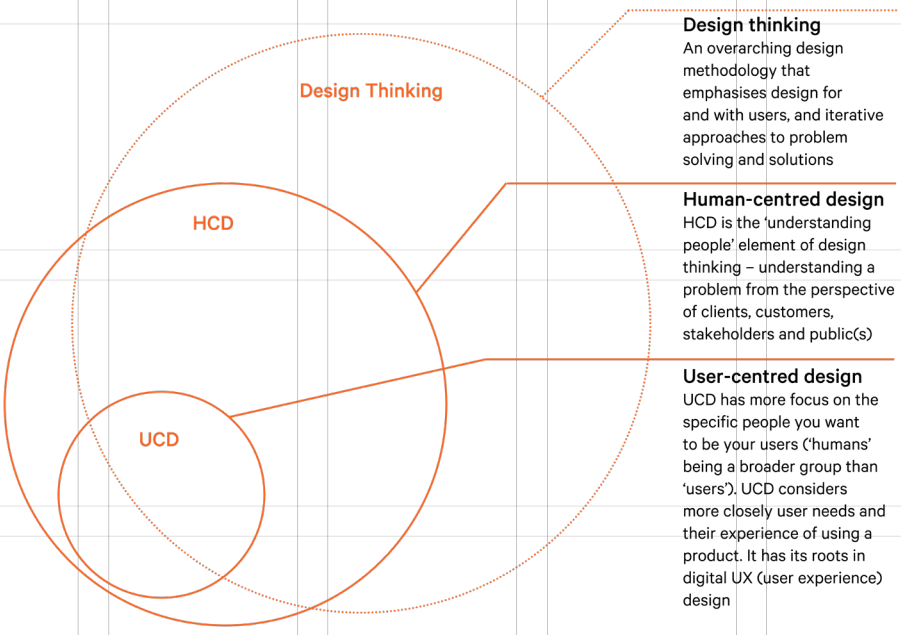



Figure 9: Design thinking, and human-centred design are often used as synonyms, as are human-centred design and user-centred design. Usually, this is acceptable and expedient, but it is possible to frame UCD as a subset of HCD, and consider HCD as a vital part of a design thinking approach.

Where calling a person a 'lightswitch user' would sound a bit odd, to call someone viewing a poster 'a user' would be nonsensical. Hence, HCD covers a broader group (and UCD may be considered as a subset of it). HCD also suggests a shift towards techniques which communicate, interact, empathise and stimulate the people involved (Giacomin, 2014), obtaining an understanding of requirements (needs, wants, experiences) which often transcends that which the people themselves would have been able to articulate prior (Giacomin, 2014). So far, so product-focussed. But, HCD has also been considered more than this too: It has been argued 'that its primary

purpose is in supporting human dignity' (Richard Buchannan, quoted in Bowen, 2009, p.27). In this project, HCD will be employed as part of a design thinking approach to the problem(s) and question(s) that arise. Rough prototyping, testing, reflecting and iterating will be undertaken in as many situations as possible. Ideally, 'users' will be identified to participate in the process (which may necessitate finding representatives of 'publics' that are the targets of research). Using UCD tools such as the development of personas (composite people based on research developed to represent a target group) might help target science communication, or act as a reflexive tool for scientist-communicators to 'design' their engagement activities for.

### Participatory design or codesign

The terms participatory design, codesign and cocreation describe the practice of collective creativity of designers and people not trained in design, applied across the whole span of a design process (Sanders & Stappers, 2008). It directly involves 'people in the codesign of artefacts, processes and environments that shape their lives' (Simonsen & Robertson, 2013, p.2). Though some researchers have indicated subtle differences (for instance Bowen (2009, p. 56) suggests codesign has less of a political underpinning and is more product focussed), participatory design and codesign are generally used synonymously. Cocreation is a broader term that simply suggests collective creativity, and as such can include codesign practices.

| **Cocreation** | |
|---|---|
| Cocreation refers to any act of collective creativity, i.e. creativity that is shared by two or more people. | |
| **Codesign**<br>(synonym: participatory design)<br>(accepted by Sanders & Stappers, 2008) | **Codesign**<br>(alternative understanding) |
| Collective creativity as it is applied across the whole span of a design process. Thus, co-design is a specific instance of co-creation and refers to refer to the creativity of designers and people not trained in design working together in the design development process. | Collective creativity as it is applied across the whole span of a design process. |

Table 1: Definitions of cocreation and codesign, adapted from Sanders & Stappers (2008, p.6)

Participatory design has its roots in Scandinavian workplaces in the 1970s, where a concern about technology (notably computers) devaluing and deskilling workers (Bowen, 2009) led to an attempt to enable workers to have more influence on these systems to promote the quality of working environments. This genesis led to two hallmarks of participatory design:

— stakeholders have a democratic right to be included in its design and will benefit as a result;

— including stakeholders in design activities results in better technical systems (for example more efficient, more usable, more profitable).

In turn, this approach should produce 'happier' (empowered, enabled, fulfilled) stakeholders and better products/productivity (Bowen, 2009, p. 53).

These attributes have clear synergies with the conception of 'upstream' participation and engagement between science and society.

There was a parallel participatory design developing at the same time (Sanders & Stappers, 2008; Kerridge, 2015) via the Design Research Society in the UK, which also has this emphasis on the benefits of citizen participation. In 1971 they held a conference called Design Participation with contributors from the fields of economics, design, architecture, planning, building science, design research, and mechanical engineering, and in the proceedings, Nigel Cross stated:

**...professional designers in every field have failed in their assumed responsibility to predict and to design-out the adverse effects of their projects. These harmful side effects can no longer be tolerated and regarded as inevitable if we are to survive the future ... There is certainly a need for new approaches to design if we are to arrest the escalating problems of the man-made world and citizen participation in decision making could possibly provide a necessary reorientation. Hence this conference theme of 'user participation in design'.**

**(Cross, 1972 in Sanders & Stappers, 2008, p.7)**

Participatory design differentiates itself from other traditions by seeking 'genuine participation' (Kensing & Greenbaum, 2013, p.27), placing less value on techniques such as interviews or focus groups, which can be construed as one-way approaches. Though all of these data gathering exercises may be employed within this project, participatory design approaches may offer a framework for the development of workshops, especially during planning engagement strategy or activities for Te Pūnaha Matatini (see the project plan section). In addition, participatory design has been seen as a mechanism for disrupting existing power structures (Sanders & Stappers, 2008, p.9) because power needs to be relinquished by companies or institutions (or perhaps in this context by 'science') as publics (users, stakeholders, customers...) are given a genuine say. Sanders & Stappers (2008, p.9) state that this makes 'participatory thinking...antithetical to consumerism'. In challenging the status quo, this makes it a valid tool in a situation where there is a genuine desire to know (and act on) how the public feel about science and technology.

***Critical design***
**'...seeks to avoid conventional production and consumption, offering an alternative use... [it] can be used to mobilize debate and inquire into matters of concern through the creative process involved in designing objects'**

Malpass
2016, p.2

## Critical design

Critical design is one of a growing number of approaches that aim to 'present and define interrogative, discursive, and experimental approaches in design practice and research' (Malpass, 2016, p.4). It is located outside normal models of design, in that it is generally undertaken 'for exhibit rather than sale' (Malpass, 2009, p.1). It is socially and politically engaged, and can be considered a kind of creative activism which seeks to provoke reflection on pertinent societal issues (Malpass, 2016, p.6), and can 'serve as a resource for supplementing STS conceptualisations of, and practices toward, public, engagement, and science' (Michael, 2012, p. 528).

In contrast to 'regular' design (which Malpass (2016) terms 'explanatory'), critical design is 'affective'. That is, rather than offering solutions to design problems, it poses questions and 'opens lines of enquiry' (Malpass, 2016, p.41). Or, as Ramia Mazé (2009) puts it, it is 'less concerned with problem-solving than with *problem-finding*'. Like STS, critical design has an interest in considering the implications of new areas of science and technology, which is particularly pertinent to the subset of critical design termed 'speculative design'. Speculative design uses future scenarios to pose '"what if" questions that are intended to open debate and discussion about the kind of future people want (and do not want)' (Dunne & Raby, 2013), posing questions that explore ethical and societal implications of new science, and the technology that enables or distributes it.

Critical design can mesh with other related practices and disciplines and borrow methodologies as appropriate, for instance 'combining anthropological-style observation and speculation on emergent social practices' (Escobar, 2018, p. 54; Gunn, Otto, & Smith, 2013) to develop a distinct style of knowledge. It 'legitimately uses tools, techniques, instruments, methods, genres and concepts such as fictional narratives, film language, screenplay, storyboard, user testing, interviews/questionnaires, games, but also media and pop culture phenomena...Anything considered suitable at a given moment is legitimate' (Mitrović, n.d.).

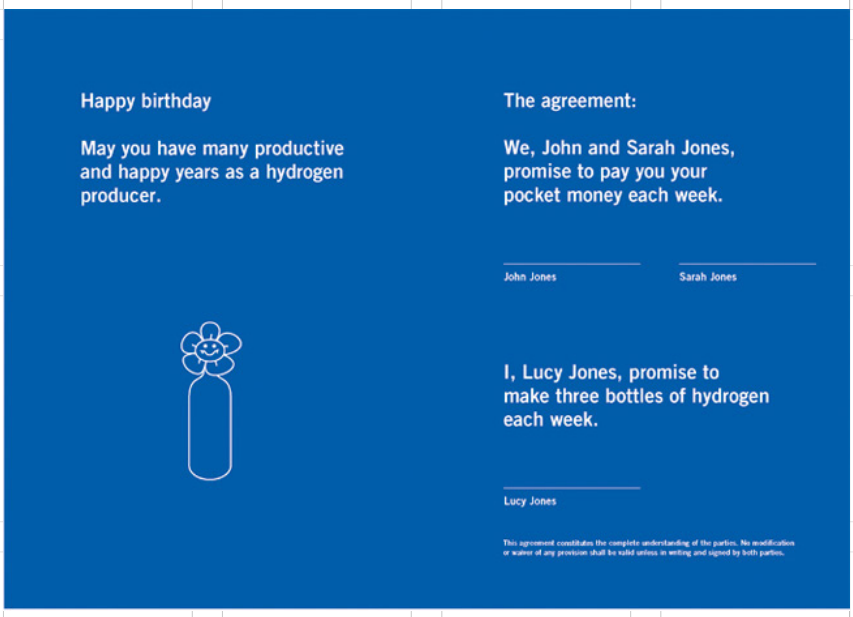
An example of an interdisciplinary codesign and speculative design approach is Energy and Co-Designing Communities (ECDC), a collaboration between Design and Sociology departments at Goldsmiths University of London (Wilkie, 2015). It blurred the lines between ethnographic research and speculation (Malpass, 2017, p.73), and through an iterative design approach (including codesign workshops and ethnographic research, and a two year process of design, testing and fabrication) produced a 'domestic appliance' product. This was *Energy Babble* (figure 10), a device placed in thirty homes around the UK. It was a machine that recieved and broadcasted 'babbles', 'Synthesised voices, punctuated by occasional jingles, [that]

recount energy policy announcements, remarks about energy conservation made on social media, information about current energy demand and production, and comments entered by other Babble users' (Boucher et al., 2018, p.7). Funded by the Research Councils UK (RCUK) Energy Programme, it was a playful provocation to prompt discussion around 'the parameters of 'energy-demand reduction' (Boucher et al., 2018, p.10). The research project also worked with the participants to gain an understanding of their energy-demand reduction activities, and how their practices and communities had been shaped through the intervention of the device (Wilkie, 2015).

Figure 10: The Energy Babble and associated design process material (Wilkie, 2015) https://easst.net/article/the-energy-babble-part-of-the-energy-and-co-designing-communities-project-ecdc/

Critical design has largely been experienced within a gallery context. For example, the 2004 project *Is this your future?* was a critical design experiment commissioned by the Science Museum in London (Dunne & Raby, 2004). Dunne & Raby exhibited a collection of hypothetical products to explore the ethical, cultural and social impact of different energy futures. The scenarios included domestic hydrogen production; bio-fuel created from human waste; and meat-based microbial fuel cells. Each scenario is based on a real technology and asks what would happen if this became the main form of energy in the not too distant future. It communicates a set of values driven by social as well as technological changes through using design of 'new everyday objects' to help audiences speculate about the future (figure 11).

Galleries attract a specific audience, which perhaps means as an engagement activity, the participants become somewhat self-selecting, and as Bowater & Yeoman (2013, p.17) suggest (with regards to upstream engagement activities), this makes them unlikely to represent the public as a whole. Other projects try and utilise space in which the public can 'happen upon' their interventions. Maja Horst is a social scientist who collaborated with spatial designer Birte Dalsgård in order to create debate and reflection about the regulation of and expectations towards new technology (Horst, 2011). This took place through a spatial installation in public places such as a shopping centre (figure 12), to communicate social science research.

Happy birthday

May you have many productive and happy years as a hydrogen producer.

The agreement:

We, John and Sarah Jones, promise to pay you your pocket money each week.

John Jones

Sarah Jones

I, Lucy Jones, promise to make three bottles of hydrogen each week.

Lucy Jones

This agreement constitutes the complete understanding of the parties. No modification or waiver of any provision shall be valid unless in writing and signed by both parties.

Figure 11: Artifacts from a scenario about domestic hydrogen production and child labour with specially designed family uniform and corporate logos On the right, a parent-child contract making the child responsible for home hydrogen production on their 8th birthday The audience was children aged 7-14 year, hence the scenarios were relatable to this audience (Dunne & Raby, 2004) http://www.dunneandraby.co.uk/content/projects/68/0w

Figure 12: Maja Horst's 2007 installation exhibited in a public place where people naturally pass by: a shopping mall near Copenhagen. (Horst, 2011) www.stamcellenetvaerket.dk/eng-fields.html

The rationale behind the experiment was to improve scientific knowledge production by making the researcher (in this case Horst herself) sensitive to new forms of reactions and objections. This offers the potential to instigate behaviour change in the audience *and* the researcher – an indirect two-way dialogue, perhaps?

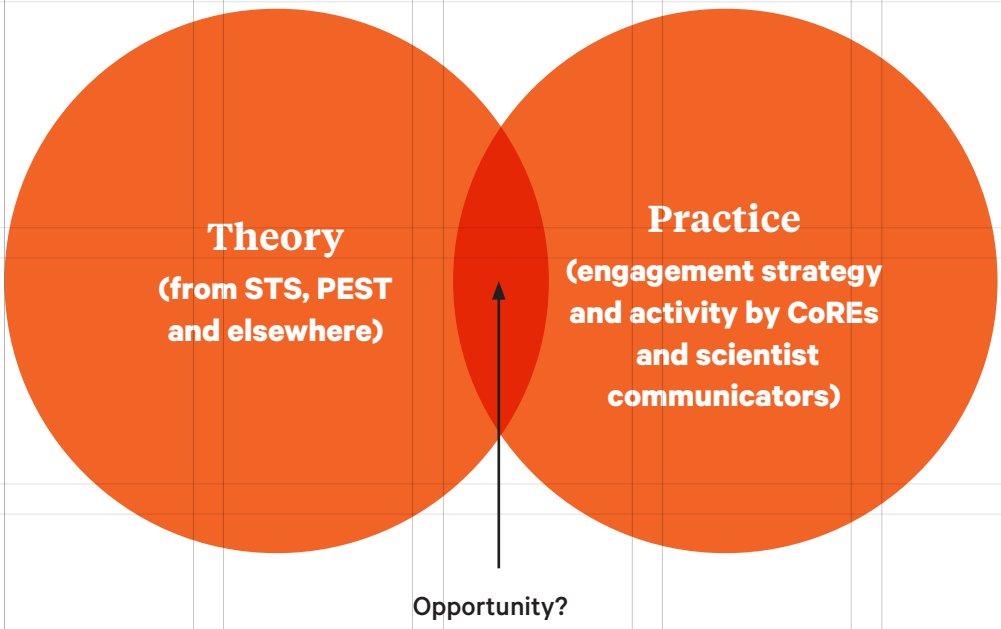
I am interested in the social science/design hybrid quality of this work, and also the potential to utilise more speculative work in public space as a way to reach people who may not self-identify as interested in science.

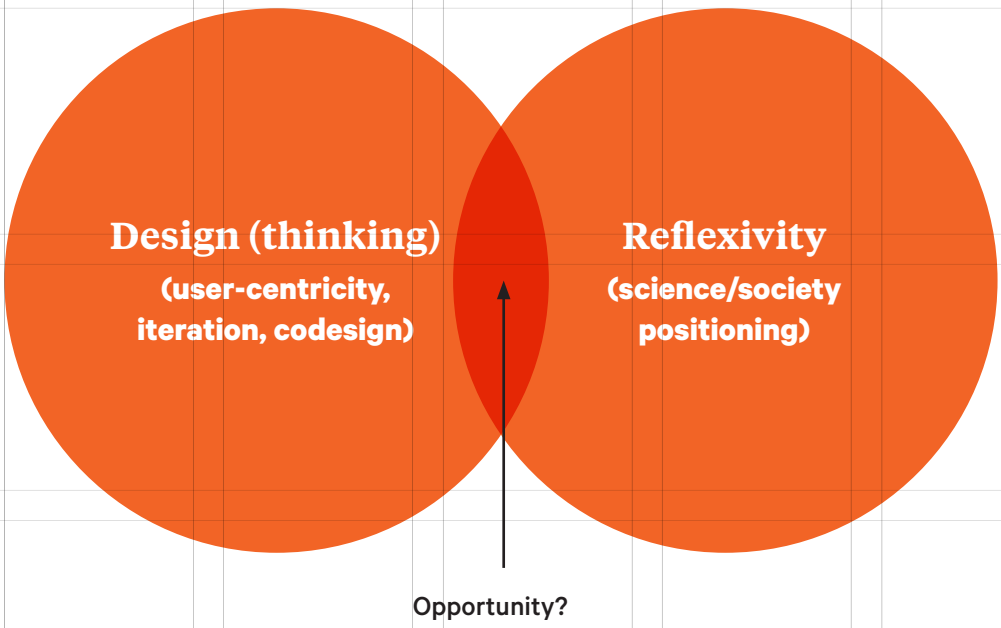
So where does this place design in this project? At the top level, design thinking processes will inform the overall 'attitude' – that empathy will need to be built with stakeholders in my project (scientist-communicators, researchers, inter-institutional research organisations), and with the 'users' or audiences that they may seek to target, and it will embed the idea that iteration is key. At another level, design may become a tool to probe, through speculative provocation, attitudes, and assumptions towards science, research (and publics). These approaches could be merged into each other, and, channelling the critical design approach of borrowing tools and methodologies from wherever is appropriate (design, anthropology and other social sciences, science itself) for the task at hand. This is 'research through design', which engages professional practice as a methodological approach to research, and is concerned with negotiating and improving 'real world' situations (then taking insights and trying to offer better ways of doing things). But, unlike the preoccupation with 'the creative individual and the aesthetic of the artefact' (Gothe, 2015, p. 28) that many people might associate with 'design', it underlines the reorientation within the design discipline towards deeper consideration of social and ethical considerations, via 'reconfigured interpersonal relations, participation and collaboration' (Gothe, 2015, p. 28). This is indicative of design – and the designer's – evolving role in scholarly enterprise, and society.

This might mean that the project will occupy a somewhat liminal space compared to PhD projects that exist within a distinct disciplinary boundary. My project is not 'practice based' in the way a literary or fine arts project may be, yet artefacts may form part of the output. To add to the ambiguity, in line with the Double Diamond approach, it isn't possible at this stage to articulate what the 'outputs' will be – the first diamond needs to determine that. However, the next section details how the contextual review and design might combine to inform a programme of research.

## *Situating:*
## Connect theory / practice
## Connect practitioner / design

Slide from December 2018 presentation



# Project plan

## Philosophical position

In determining an appropriate philosophical basis for this research, I have come to acknowledge my relatively low *explicit* awareness of my own philosophical position, which I am now seeking to expand, articulate and reconcile with how I *instinctively* practice as a designer.

In dealing with the work of scientists on one hand with their (assumed) objectivist position, and the influence of PEST and STS (most of whose practitioners subscribe to some form of subjectivism (de Laet, 1997)), it feels once again like design is oscillating between. Design does have a history of being pulled both ways – on one hand being 'scientised' (notably by the 'design methods movement' in the 1960s) and on the other, Schön and others putting forward an explicit 'challenging of the positivist doctrine underlying much of the 'design science' movement, and offer[ing] instead a constructivist paradigm' (Cross, 2001, p.4). It seems that a position triangulated between these objective and subjective poles could be the most productive.

Critical realism originated in the work of Roy Bhaskar in the late 20th century, 'as a response to both positivist direct realism and postmodernist nominalism...and occupies a middle ground between these two positions' (Saunders, Lewis, & Thornhill, 2009, p. 139). Andrew Sayer (2002) explicitly positions critical realism against forms of 'methodological imperialism', with scientism on one side, with its 'absurdly restrictive view of science', and on the other, 'that which tries to reduce social science wholly to the interpretation of meaning' (Harris, 2018a).

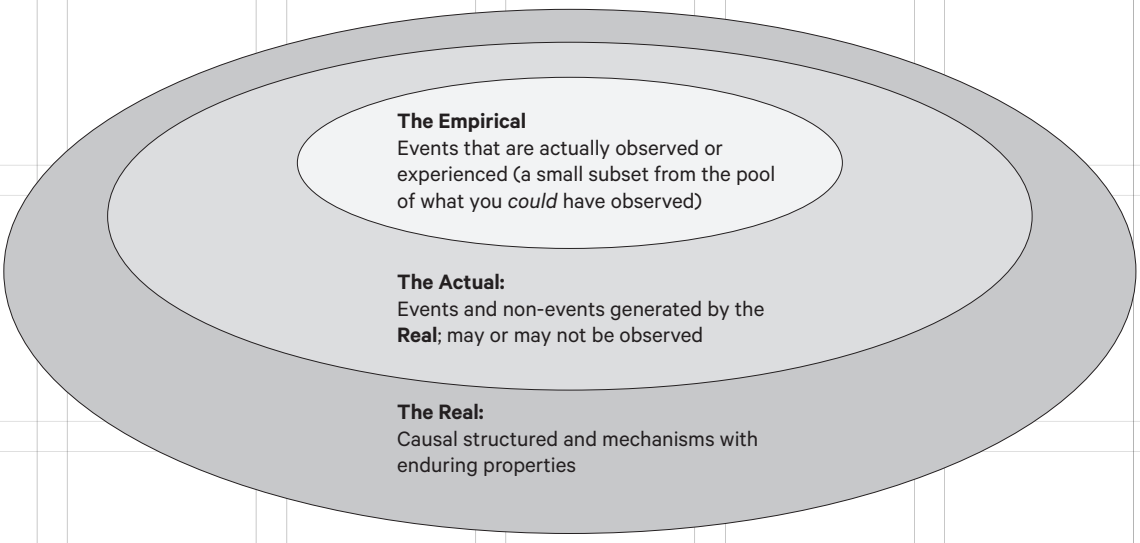



Figure 13: Critical realist stratified ontology, developed from Bhaskar (1978). (Saunders, et al. 2009, p.139)

Critical realism holds that a stratified ontology (figure 13) is crucial (Saunders, et al. 2009). That is, reality is 'external and independent, but not directly accessible through our observation and knowledge of it', so instead we experience ''the empirical', in other words sensations, which are some of the manifestations of the things in the real world, rather than the actual things' (Saunders, et al. 2009, p.139) (figure 13). Critical realism accepts that there is 'a real, but imperfectly apprehensible, world 'out there' to discover... and that reality is both complex and changing' (Withell & Haigh, 2018, p.321).

In terms of the axiological position of critical realism, this 'follows from the recognition that our knowledge of reality is a result of social conditioning ... and cannot be understood independently of the social actors involved' (Saunders, et al. 2009, p.140). As a result, Saunders, et al. (2009) suggest, a critical realist researcher would seek to make themselves aware of how personal experience and socio-cultural background could cause bias in their research, and minimise these influences. In terms of my approach to my own research, this is certainly something I am cognisant of and striving to address through personal reflexivity.

| Critical Realism | | | |
|---|---|---|---|
| **Ontology** | **Epistimology** | **Axiology** | **Typical methods** |
| Stratified/layered (the empirical, the actual and the real)<br>External, independent<br>Intransient<br>Objective structures<br>Causal mechanisms | Epistemological relativism<br>Knowledge historically situated and transient<br>Facts are social constructions<br>Historical causal explanation as contribution | Value-laden research<br>Researcher acknowledges bias by world views, cultural experience and upbringing<br>Researcher tries to minimise bias and errors<br>Researcher is as objective as possible | Retroductive, in-depth historically situated analysis of pre-existing structures and emerging agency. Range of methods and data types to fit subject matter |

Table 2: the positioning of a critical realist research philosophy (Saunders, et al. 2009, p.136)

## Research aims and objectives

The contextual review revealed that there is a gap between social science theory pertaining to science communication and public engagement, and scientist-communicators who are designing and undertaking public-facing activities. Inter-institutional research organisations like CoRES and NSCs have a mandate to 'do' engagement, but there is a lack of clarity about how this should be undertaken and measured. In addition, reflexivity has been proposed as a way to help scientist-communicators improve the 'calibre and clarity of activities that are designed to support enhanced public engagement with science and technology' (Salmon, et.al., 2017, p.53). These observations have been developed via literature review, initial interviews, and anecdotally

through conversation with the Aotearoa New Zealand scicomm community.

This naturally leads to questions such as:

**How would public engagement strategy and delivery be different (would it be more successful*) if practitioners were connected to public engagement with science and technology (PEST) theory?**

**Can reflexivity help scientist-communicators and inter-institutional organisations research organisations better consider their work in a science/society context? And will this influence subsequent engagement/ lead to more successful* engagement?**

**How does the Aotearoa New Zealand science communication community understand terminology such as science communication, public engagement and outreach? How does this compare to international understanding?**

**How are inter-institutional research organisations making strategic decisions about public engagement?**

**Are there commonalities in the way scientist-communicators who have been recognised for their excellence plan and 'perform' engagement?**

***Appropriate measures of success need to be determined on a project-by-project basis**

To interrogate these questions, practice-led design research will be used as a mode for exploring potentialities, posing the question, where are the opportunities for design to add value? Is it possible to design 'the communicating of science communication theory'? Can introducing scientist-communicators and the research networks they work in to design thinking processes lead to greater user-centricity, more iterative approaches, and a better idea of what a successful engagement is before they do it? And can this happen through encouraging a reflexive attitude to help them consider their work in a science/society context? Bearing in mind the design process specifically cautions against 'solving the wrong problem' by rushing or missing out the discover and define phases, my overarching research question is deliberately broad at this stage:

## How can design be used to improve public engagement with science and technology in Aotearoa New Zealand?

In essence I want to probe the question, can using human-centred design processes with scientist-communicators and the research networks they work in to lead to greater user-centricity, more iterative approaches, and a better idea of what a successful engagement is before they do it? There is the potential for this to default to using design as a mechanism to make 'best practice' easier to access and consume for scientist-communicators, and this may form part of the

development. But, I am mindful that I don't just want to one-way communicate ways to understand the benefits of a dialogue approach. I don't want to make communication more shiny and professional. If dialogue approaches are less patriarchal, more inclusive, more transparent about science, how, reflexively, can that be encouraged to happen through design?

Is there scope to use design to help organisations and the scientist-communicators in them be more reflexive by considering not, in the first instance at least, how to make the communication better, but to consider the motivations for communicating in the first place? Thinking about how contentious the research might be, at what state it's happening, and how much the agenda might be shaped by the public – and being honest about this – could help transparency and reflexivity. Understanding, for instance, that what you are doing is being a cheerleader for your research, not being an advocate for more transparency in science (or vice versa) is a useful reflexive shift. If we talk about publics and think about potential audiences as essentially the humans in a human-centred design process, can we be more user-centric, and more honest about what we are doing? HCD suggests a shift towards techniques which communicate, interact, empathise and stimulate the people involved, and is one way I see design offering value in this area.

## Research streams

At this stage, I am suggesting research in several streams (figure 14):

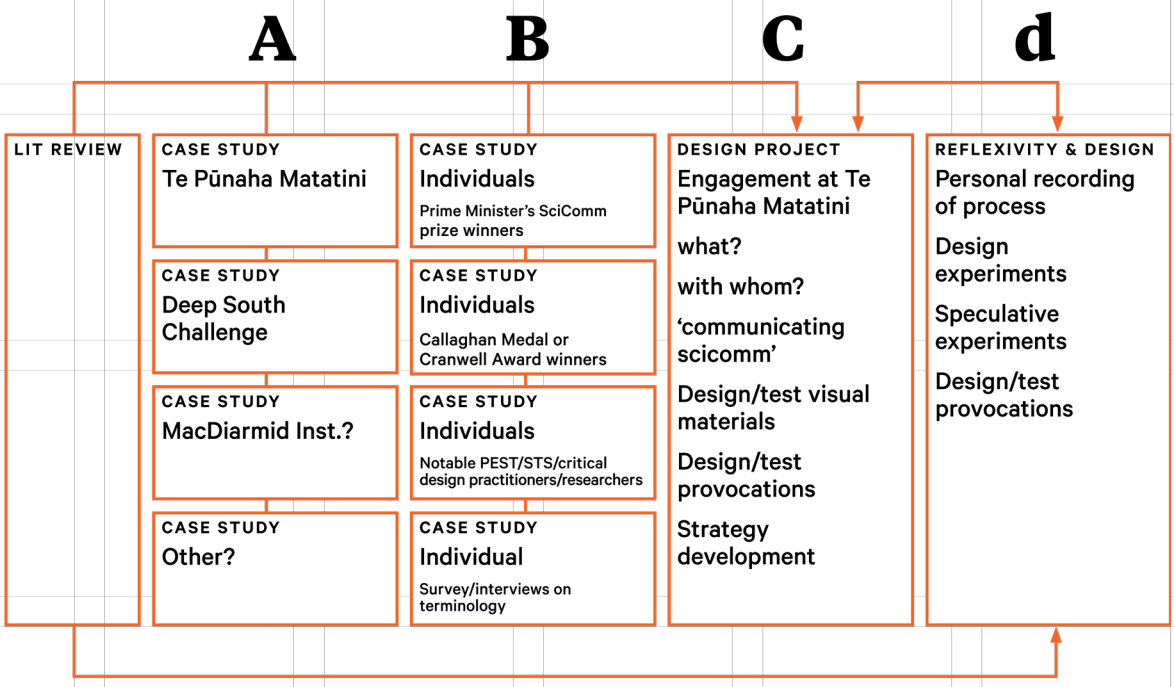



Figure 14: Suggested research streams. Arrows denote direction of influence

I acknowledge that I am operating at present in a 'divergent' phase vis-à-vis the 'Double Diamond' (figure 8), and synthesis will need to occur to narrow the scope.

It should be noted that these streams do not occur one after the other, they will occur largely concurrently. Further literature review and collection of secondary data (examples of engagement outputs and applied use of design to underpin engagement, for example) will be conducted to support each stage. In terms of my own data collection, my proposed research streams are:

## Research stream A: understanding inter-institutional research organisations' approach to engagement

**Key question: how is engagement understood, and how has strategy been developed in inter-institutional research organisations in Aotearoa New Zealand?**

Stream A will comprise of a series of case studies of inter-institutional, cross-disciplinary research networks, or organisations that have 'public engagement' explicitly stated as an objective or performance measure. These will include the CoREs (Te Pūnaha Matatini), and the National Science Challenges 'The Deep South' (and potentially one or two others). These organisations were chosen because they have a specific mandate to undertake engagement as part of their funding arrangements. This stream will seek to understand how engagement is understood and implemented in these organisations: how is strategy formulated; how is engagement perceived (is it 'social good', is it PR, Is it upstream or downstream?); is there a defined process they undertake to codesign their strategy, etcetera. Sarah Davies studied the meanings and genealogies of PEST within UK Beacons for Public Engagement (Davies, 2013), and this study provides a useful template of approaches and data to compare against, with my research bringing a specifically Aotearoa New Zealand perspective.

This stream will take the form of archival research, followed by a semi-structured qualitative study (Blandford, 2013) incorporating some elements of surveys/semi-structured interviews/workshops. Within the interview process, a generalised framework will be used to aid the documentation and coding of information, using the guiding taxonomy such as the 'AEIOU: Activities, Environments, Interactions, Objects, Users' classification (Martin & Hanington, 2012, p.10). This framework will also aid the collection and cataloguing of other observational information, such as visual documentation of outputs. Subsequent contextual affinity diagramming (Martin & Hanington, 2012, p. 12) will be used to interpret interview themes and commonalities. A structured thematic analysis may be undertaken, if considered appropriate.

## Research stream B: understanding scientist-communicators' approach to engagement in Aotearoa New Zealand

**Key questions: how is engagement (and associated terms) understood by scientist-communicators in Aotearoa New Zealand? How is their engagement planned? Is it informed by PEST theory? Are there commonalities across practitioners? What are the drivers to scientist-communicators undertaking engagement? Are there commonalities in the way scientist-communicators who have been recognised for their excellence plan and 'perform' engagement?**

The second strand, B, will focus on individual scientist-communicators in two groups: recognised scicomm 'superstar scientists 'who have been recognised with prestigious prizes (Salmon & Priestley, 2015, p. 103) and the scientist-communicator community more generally.

In the first instance, a survey will be used with scientist-communicators and the wider science communication community in Aotearoa New Zealand to identify if the general understanding of science communication, public engagement and outreach are consistent with aspects of the (itself inconsistent) literature. This will leverage the UK-based survey by Illingworth, Redfern, Millington, & Gray (2015), but will be tailored to our local context. I have undertaken an initial run of this survey with Te Pūnaha Matatini investigators, and it is broadly consistent with the idea that terms are used interchangeably. This may extend to short, remote interviews that could pick up some of the themes identified by Winstanley & Hepi (2012).

Secondly, this stream will focus on high profile scientist-communicators and how they plan and deliver engagement (and will also cover how they understand the PEST terminology, and how they are (or are not) informed by theory). It will consider individuals who have been recognised for their science communication and engagement, such as winners of the Prime Minister's Science Communication Prize[1], Callaghan Award[2] (Royal Society Te Apārangi ) or Cranwell Medal[3] (NZAS) (acknowledging that there is

1 The Prime Minister's Science Communication Prize is 'awarded to either a practising scientist who can demonstrate an interest, passion and aptitude for science communication and public engagement, or to a person who has developed expertise in public engagement with, or communication of complex scientific or technological information to the public.' ('The Prime Minister's Science Communication Prize | The Prime Minister's Science Prizes', n.d.)

2 The Callaghan Medal is awarded annually to a person who has, while in New Zealand, made an outstanding contribution to science and/or technology communication, in particular raising public awareness of the value of science and/or technology to human progress.' ('Royal Society Te Apārangi - Callaghan Medal', n.d.)

3 'The Cranwell Medal is awarded to a practising scientist for excellence in communicating science to the general public in any area of science or technology. In 2017 this medal wa s renamed from the Science Communicator Medal to honour the botanist Dr Lucy Cranwell, a remarkable communicator of science – in a time when this was essentially unheard of.' ('New Zealand Association of Scientists - Cranwell Medal', n.d.)

significant crossover between these groups). As with stream A, this will include semi-structured interviews (similar to the ones I have already conducted). It may also involve methods to probe reflexivity around engagement, such as journaling or blogging, and after the initial interviews, activities such as codesign of research-focussed visual materials (for instance, joint development of visual abstracts, or presentations) may follow. In a different mode, it may also include tools like 'design probes' – resources to playfully elicit information, for instance, encouraging the personal mapping of variables and relationships (Gaver, Boucher, Pennington, & Walker, 2004). This kind of method may encourage reflexivity, and though design or cultural probes are usually given as tasks for the subject to complete autonomously via 'kits' containing 'tasks', they could loop into further codesign exploration. Probes are not intended to be formally analysed (Martin & Hanington, 2012). The approach values 'uncertainty, play, exploration, and subjective interpretation' (Gaver, et al., 2004, p.53). Results can be surprising, and directly 'interpreting' them may be impossible, but perhaps the value is in the act of bringing to the surface how a scientist-communicator feels about issues such as, for instance, the organisational expectations and constraints on their engagement. As Gaver et al. (2004, p.55) point out, whereas most research techniques 'seek to minimise or disguise the subjectivity of this process through controlled procedures or the appearance of impersonality', the Probes purposely seek to embrace it', and as such add an interesting dimension. Through this stream, I hope to get a sense of how these lauded scientist-communicators operate, identifying commonalities and differences, and also considering if they have approaches or strategies that could be utilised in my stream C research.

Te Pūnaha Matatini list many of Aotearoa New Zealand's recognised and awarded scientist-communicators amongst their investigators. I am cognisant that as a researcher obtaining funds from Te Pūnaha Matatini, and acknowledging that I will work with some of these people in several guises that this may pose ethical conundrums. This is an issue I will navigate in consultation with my supervisory team (one of whom, to add another strata of potential conflict-of-interest, is a Prime Minister's Science Communication Prize winner).

In addition to work with the high-profile scientist-communicators, I will also look to investigate practitioners who represent approaches from STS, critical design and science communication, such as the work of Maja Horst (see pp.41-42). I'm also interested in the work of design practitioners who have a lens that is very similar to STS in terms of provoking questions about how science impacts society and vice versa. I'm thinking particularly of the work of critical designers like Dunne & Raby and Natalie Jerimijenko.

This may form part of the literature review (and as such act as a prompt in streams C and D), or may extend to interviews or correspondence, or focus groups /workshops.

## Research stream C: experimental engagement development

**Key question: What could engagement strategy and delivery look like if it was designed?**

The third C stream is a place to play and try out ideas. Te Pūnaha Matatini are part of this stream, and there will be TPM personnel involved in stream B. And, they are also a testbed for experimental approaches to strategising and improving engagement in this stream.

I am embedded[4] on the Te Pūnaha Matatini 'outreach and engagement' committee to gain a sense of their needs and wants regarding PEST approaches. I assisted Rhian Salmon in running a workshop session at their annual hui (October 2018) where we asked the researchers what they thought was important in terms of TPM's engagement with the public. This was formed around questions such as: what are the organisation's engagement goals, and how do these interface with overarching organisational goals; what does engagement *mean* to TPM; is there a shared understanding of terminology; is the purpose showcasing individual projects/research, or advocating for science more generally, or to present a unified view of TPM's programme? The workshop yielded some interesting (very preliminary) results, and made me think about the positioning of approaches on axes such as those in figure 4: the timing of research, the level of controversy, the degree of impact the public might have on direction, etcetera.

With the engagement committee I intend to use some design thinking approaches, especially codesign workshopping, to step through the design process, and see if that produces a different outcome to the modes of operation I've discovered in stream A. This may include tasks like the development of projective generative design (Martin & Hanington, 2012), such as modelling 'material totems' (visualising emotion or situation with clay or other making materials) as part of what Brueggemann, Strohmayer, Marshall, & Birbeck (2017) term an ethno-empathy approach. This stream of

4 In this context, I mean embedded as a kind of collaborative, engaged (Lewis & Russell, 2011) interface with the groups I will work with. Lewis & Russell (2011) use the term 'embedded' (in the context of their ethnographic practice) to mean research that is 'founded on the principles and practice of immersion fieldwork while being responsive to working with reflexive collaborators, adaptive to the requirements of ethics and other forms of research regulation, and accommodating to audiences eager for new forms of ethnographic output' (p.400). This pragmatic, flexible and participatory sensibility is the approach I seek to adopt (without claiming a grounding in traditional participant observation as the underpinning method or methodology).

research may involve the development and evaluation of new engagement activities alongside strategy approaches (though this is contingent on running through the first half of the Double Diamond with regards to TPM's engagement strategy).

## Research stream d: personal reflexive practice and design sandbox

The d stream, which is secondary, hence lower case, is just about me. It is about me making space in the project to play around with things that I feel might be interesting, and inject them back into the project; where critical design approaches, such as the examples on pp.39-41, might be utilised. Can I develop design-centric responses or provocations to issues I am encountering that might act as catalysts to the discussion of science and society issues in stream C? Or will design simply act as a tool to document, visualise and process.

And finally, this stream is also a space for reflexive documentation and consideration of my experience, and about a transparent, open-book research approach to undertaking a PhD. It is where I will cogitate about issues such as ethics: of my own work, of elements within the research, and of science in society.

# Project management

## Thesis outline

This is a draft structural outline for the PhD thesis showing the general areas I anticipate being covered. There will be a 'stream d' reflexive dialogue thread throughout the thesis, articulating in a separate-yet-connected way personal observations from the process:

**Abstract**

**TOC**

**Values statement**

**Chapter 1: Introduction**

**Chapter 2: Literature Review**

Engagement and science communication
Vocabulary and nomenclature
Design led engagement strategy
Design led engagement delivery

**Chapter 3: Research design**

Philosophy
Description of methods
Evaluation of methods

**Chapter 4: Findings**

Scicomm landscape in Aotearoa New Zealand findings
Inter-institutional research organisation findings
Scientist-communicator findings

**Case study: revised engagement strategy design (pilot)**

**Case study: examples of design interventions**

**Chapter 5: Discussion**

Significance
Future research

**Chapter 6: Conclusion, Limitations**

**End matter**

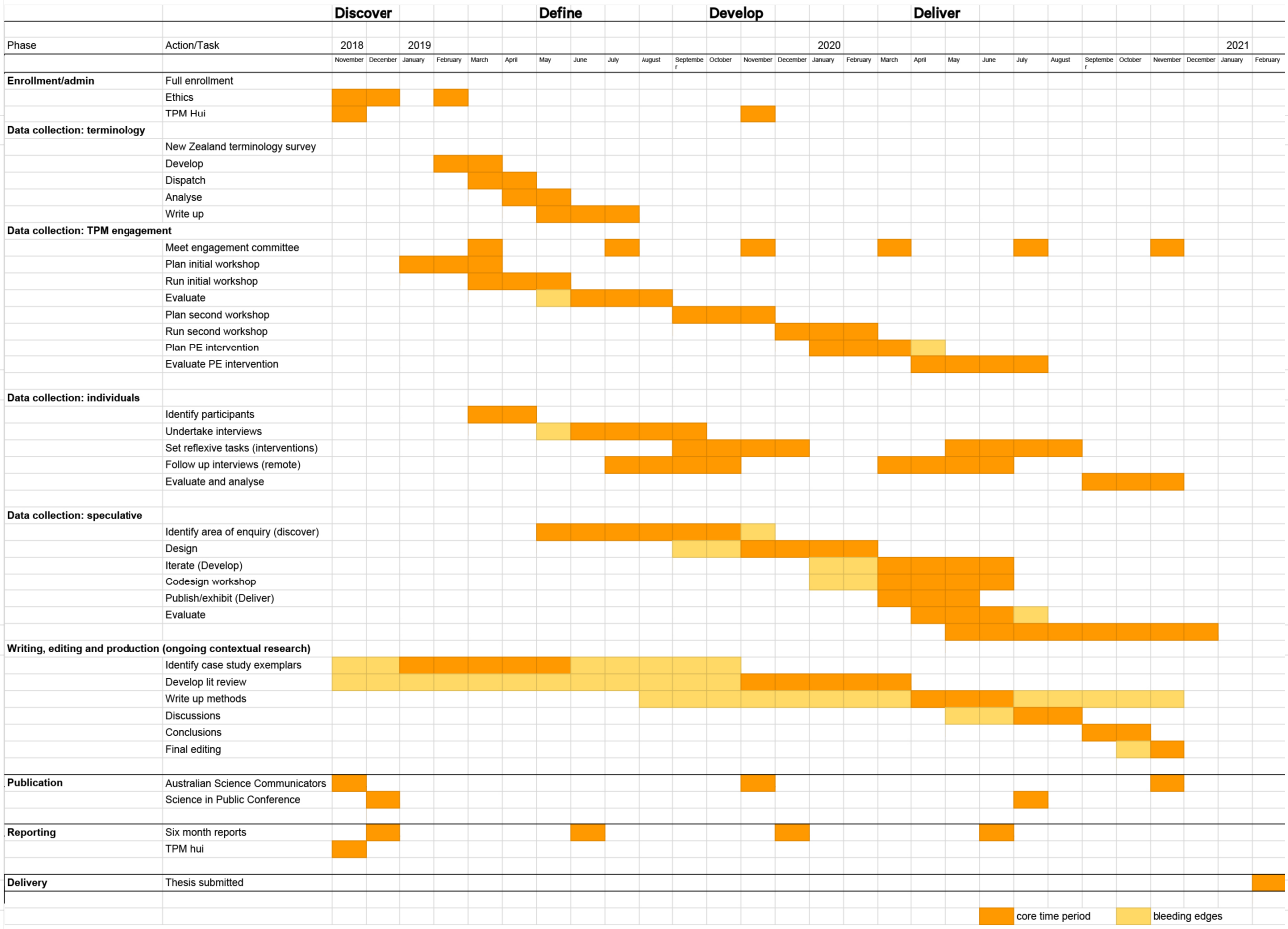
**Glossary**

**Appendices**

**References**

# Timeline

full size version at: https://tinyurl.com/baileyphd



### Budget

Most materials will be covered via scholarship, or via Te Pūnaha Matatini Engagement and Outreach Committee budget, or via *The reflexive scientist* research funds held by Rhian Salmon. Conference costs will be partly shared with Massey University:

| Item | Cost |
|---|---|
| Target conferences: Australian Science Communicators (venue TBC) 2019/2020; Science in Public 2019 (Manchester, UK) (and potentially 4S, PCST or a design conference) | TBC |
| Cocreation workshop 1 (materials, catering, venues) | $800 |
| Cocreation workshop 2 (materials, catering, venues) | $800 |
| Transport for interviewing participants (to be kept to a minimum by combining with TPM activities) | $2,000 |
| Transcription costs | $2,000 |
| Potential engagement activities | TBC |
| Prototyping materials | $2,000 |
| **Total** | **$7,600 + TBC lines** |

## Other considerations

### Ethics

In accordance with Victoria University's Human Ethics Policy, an initial application for interviews was approved in November 2017 (0000025554). This will be amended, or further approvals will be sought for other activities such as participatory design workshops. All work will be carried out in accordance with the relevant parts of the Ethics Policy.

### Cultural, social or legal impediments

I do not foresee any cultural, social or legal impediments to the successful completion and/or publication of this research at this time.

### Intellectual property

There are no intellectual property issues known at this time.

# Glossary

This glossary contains abbreviations and definitions of some terms used in this proposal. Multiple definitions exist within established literature – the ones listed here most closely fit with this project's approach and are working versions for initial stages of the research project:

### AAAS

American Association for the Advancement of Science

### Centres of Research Excellence (CoREs)

The Aotearoa New Zealand Centres of Research Excellence (CoREs) Fund was established in 2001 to encourage the development of excellent tertiary education-based research that is collaborative, strategically focused and creates significant knowledge transfer activities. Funded by the Tertiary Education Commission, CoREs are inter-institutional research networks, with researchers working together on commonly agreed work programmes. They are, by this research's definition, inter-institutional research organisations. https://www.tec.govt.nz/funding/funding-and-performance/funding/fund-finder/centres-of-research-excellence/

### HCD

Human centred design (see page 36).

### Interdisciplinary

Interdisciplinary research is Integrating knowledge and methods from different disciplines. It analyses, synthesises and harmonises links between disciplines into a coordinated and coherent whole. Is like a melting pot (such as a fondue or stew, in which the ingredients are only partially distinguishable). Interactive, 2 + 2 = 5. Nikolov(a) et al., (n.d.); Jensenius (2012).

### Inter-institutional research organisation (or network)

Inter-institutional research networks (or organisations) refers to entities such as Centres of Research Excellence (CoREs), where researchers come together from different institutions, or National Science Challenges, where projects are cross-disciplinary and mission-led.

### National Science Challenges (NSCs)

The National Science Challenges are cross-disciplinary, mission-led programmes designed to take a strategic approach to the Government's science investment by targeting a series of goals, which, if achieved, would have major and enduring benefits for New Zealand. They require collaboration between researchers from universities and other academic institutions, Crown research institutes, businesses and non-government organisations to achieve their objectives They are, by this research's definition, inter-institutionalresearch organisations. https://www.mbie.govt.nz/science-and-technology/science-and-innovation/funding-information-and-opportunities/investment-funds/national-science-challenges/

### PAS
Gilbert, Stocklmayer, and Garnett (1999) define the public awareness of science (PAS) as a set of positive attitudes toward science (and technology) that are evidenced by a series of skills and behavioral intentions.

### PUS
Public Understanding of Science. 'Public understanding of science, as the name suggests, focuses on understanding science: its content, processes, and social factors.' (Burns, et al., 2003, p.190) There is an academic journal of the same name.

### PES/PEST
Public Engagement with Science (and Technology).'The AAAS describes public engagement with science as intentional, meaningful interactions that provide opportunities for mutual learning between scientists and members of the public'. Nisbet & Markowitz (2015, p.2), state that public engagement is 'intentional, meaningful interactions that provide opportunities for mutual learning between scientists and members of the public', and is generally considered to be (or is aiming to be) a two-way dialogical process between science and society.

### Reflexivity
Reflexivity is an attitude of attending systematically to the context of knowledge construction, especially to the effect of the researcher, at every step of the research process (Cohen & Crabtree, 2006).

### Scicomm
Scicomm is a frequent abbreviation for science communication, and #scicomm is a well-used Twitter hashtag. The double-m tends to be used over scicom to distinguish from commercial, as in .com.

### Science communication
Horst, Davies & Irwin (2017, p.884) define science communication as 'organised, explicit, and intended actions that aim to communicate scientific knowledge, methodology, processes or practices in settings where non-scientists are a recognized part of the audience'. An alternative definition from Mellor & Webster (2017, p.1) states science communication is 'An umbrella term covering a wide variety of activities, including, professional communication by scientists; interactions between scientists and members of the public; the media representation of science; and the ways people use scientific knowledge in their own lives'.

### Scientist-communicator
Scientist-communicators is used in this proposal to differentiate scientists engaging in direct communication with non-expert audiences from both professional communicators, an approach also adopted by Salmon, Priestley, & Goven: 'In order to differentiate these activities from those carried out by people trained in PES, by institutional public-relations offices, or by the growing pool of professional engagement consultants, we refer to communication activities by scientists and science-trained communicators as 'science outreach', and to the people who initiate or carry out these activities as 'scientist-communicators'. (2017, p.54).

### SSK
Sociology of Scientific Knowledge

### STS
Science and Technology Studies

### TPM
Te Pūnaha Matatini (http://www.tepunahamatatini.ac.nz). Te Pūnaha Matatini – 'the meeting place of many faces' – is a Centre of Research Excellence hosted by the University of Auckland led by Professor of Physics at the University of Auckland Shaun Hendy. Its focus is 'transforming complex data about Aotearoa New Zealand's environment, economy, and society into knowledge, tools, and insight for making better decisions' ("About Us | Te Pūnaha Matatini," n.d.) and as such it hosts investigators and student whanau from across science and social science disciplines.

### UCD
User centred design. See page 36.

### Upstream engagement
Engagement prior to setting science research agendas or project development (Winstanley & Hepi, 2012)

### UX/UXD
User experience/user experience design.

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