Evaluating ‘Mode 2’ research: The case of The Engineering Exchange and its work related to air quality

Source: The Engineering Exchange Annual Report, 2015

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Abstract

This dissertation is a study of ‘Mode 2’ engineering research in order to explore experimental approaches to tackling problems of the environment in new ways. This is achieved through an evaluation of The Engineering Exchange’s work related to air quality. The Engineering Exchange is a UCL-based initiative that facilitates the collaboration of UCL-based engineers with community groups so that they can work together to find solutions to environmental problems.

Inventive research methods have become increasingly popular in relation to matters of the environment due to an increasing understanding of the complex nature of such problems and therefore the need to include a broader range of perspectives. The idea of a changing culture of research is expressed by the notion of a shift from ‘Mode 1’ (theoretical, experimental science) to ‘Mode 2’ (trans-disciplinary, application-focused, socially responsive) research as described in the work *Rethinking Science: Knowledge and the Public in an Age of Uncertainty* (Nowotny, Gibbons, Scott: 2001). However, existing qualitative work on ‘Mode 2’ practice has focused on its ability to produce robust outcomes and does not resituate these practices within the ideals described by the ‘Mode 2’ thesis.

Through a study of the work produced by The Engineering Exchange and semi-structured interviews with engineers, community participants and staff of the initiative, this study has evaluated ‘Mode 2’ in new ways. By comparing the accounts of engineers and community participants it found that the significance of ‘expertise’ had been replaced by a desire to gain authority for new ideas. In this case, engineers were found to be open to having their practice changed by the experience, rather than seeing their role as simply sharing their existing expertise. However, in order for these methods to achieve a wider impact further recognition of this approach is needed within institutions.

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Contents

Introduction

This dissertation will evaluate a case of ‘Mode 2’ engineering research to consider its implications for the concept of expertise and use of participatory methods in solving environmental problems. This chapter will introduce my topic and its relevance to academic debates, as well as my case study, The Engineering Exchange.

1.1 ‘Mode 2’ research

‘Mode 2’ refers to a style of conducting research that is more appreciative of the dialectic relationship between science and society as described in the work *Rethinking Science: Knowledge and the Public in an Age of Uncertainty* (Nowotny, Gibbons, Scott: 2001). The idea of a changing culture of research is underpinned by the notion of a shift from ‘Mode 1’ (theoretical, experimental science) to ‘Mode 2’ (trans-disciplinary, application-focused, socially responsive) knowledge production. Central to the argument that we are shifting towards ‘Mode 2’ is the recognition that the role of expertise in society has changed. According to Nowotny et al., with increasing numbers of experts, the public now demands greater accountability and innovation from new expertise so that it remains relevant to socially produced uncertainties (2001).

The framework of ‘Mode 2’ describes three interlinked processes that are key to this new culture of research. Firstly, a process of ‘contextualisation’ where science and society interact in new locations so that research becomes more culturally aware (Nowotny et al. 2001). Secondly, new research should now aim to become ‘socially robust knowledge’ where accountability is both socially as well as scientifically defined (ibid.). Finally Nowotny et al. argue that in shifting towards these research norms we will see a process of ‘reverse communication’ take place, whereby through continued exposure to society the ‘core’ practices of science will begin to reform (ibid.).

1.2 ‘Mode 2’ and environmental sciences

‘Mode 2’ inspired research has gained particular traction in the field of environmental science as it offers a way to grapple with the complex objects of environmental research (Barry & Born 2008) and increase the accountability of environmental experts (Whatmore 2009). Despite the tag of ‘Mode 2’ being used by both policy-makers and research institutes (e.g. the UK Treasury’s Science and Investment Framework[1], The Earth Institute, The Tyndall Centre[2]) limited empirical evaluation of these practices has been conducted. Furthermore, existing evaluations of said research have focused on the process of accomplishing the integration of multiple stakeholders and disciplines (Bruce et al. 2004, Tomkins 2005, Mansilla 2006) rather than considering the wider implications of these practices for the ‘Mode 2’ thesis.

1.3 Engineering research and publics

Engineering is a technical discipline, like science, that has traditionally not communicated well with the public (Feenberg and Callon 2010, Riley 2008). As a result a growing body of literature addresses the ways in which engineers can redress their relationship with society, particularly around issues related to sustainability (Michelfelder 2013, Poser 2013). However despite the call for more socially responsive engineers there is yet to be empirical work conducted into efforts to perform engineering research in response to demands from society. This dissertation, therefore, offers the first discussion of the influence of the ‘Mode 2’ thesis in a case of engineering research.

1.4 The Engineering Exchange

[1] Example used by Whatmore (2009) in Science, democracy and the redistribution of expertise, p.589

[2] Examples used by Barry & Weszkalnys (2013) in Multiple Environments: Accountability, Integration and Ontology, p. 7

An example of ‘Mode 2’ research is taking place in UCL’s faculty of Engineering that provides an opportunity to start such a conversation. The Engineering Exchange is an initiative based at UCL that aims to improve the engagement of local communities in engineering research. Beginning in 2014, the initiative specialises in issues related to infrastructure and the environment. The Exchange brokers partnerships between engineering researchers and community groups so that they can work together collaboratively. The Project was founded by Dr. Sarah Bell, a Senior Lecturer in Environmental Engineering, whose interest in interdisciplinary methods is visible through her research into designing sustainable urban water systems. The ethos of The Engineering Exchange is that community engagement is a two-way process, with the community benefitting from ‘leading-edge’ research outcomes, and researchers benefiting from ‘community knowledge and problem identification’ (The Engineering Exchange, Annual Report 2015). So far this initiative has developed a range of projects and forums relating to issues such as green infrastructure, transport planning and air pollution. These have involved participation from 43 UCL staff and 144 members of the public (The Engineering Exchange, Annual Report 2015). This dissertation will focus on projects related to the issue of air quality as a current environmental problem.

Source. The Engineering Exchange, Annual Report 2015

1.5 Research aims and questions

This aim of this dissertation is therefore to explore the practice of ‘Mode 2’ research using the case of The Engineering Exchange’s work related to air quality. This topic will be explored through the following research questions:

1. Did The Engineering Exchange achieve its aims related to air quality?

2. How did engineers and community members define success?

3. What were the impacts of engagement on participants?

4. What can empirical evaluation of ‘Mode 2’ tell us about this way of conducting research?

By investigating the practice of ‘Mode 2’ research using the case of The Engineering Exchange, this dissertation will contribute to the growing field of Science and Technology Studies literature that considers the changing role of expertise in society. As ‘Mode 2’ practice is often understood as a shorthand for research that better integrates science and society, the conceptual implications of these methods remain understudied. This dissertation therefore will add understanding to the wider significance of such approaches in solving environmental problems. It will also offer a novel approach to evaluating ‘Mode 2’ in order to provide insights into what these ideals mean in practice. Finally, it will provide empirical work related to the field of engineering which has thus far received less attention than that of science.

2. Conceptual framework

This section describes the background for understanding the 'Mode 2' thesis, highlighting its role in drawing together central themes within the discipline of Science and Technology Studies (STS). I will then argue that despite criticisms of 'Mode 2', this remains a vital lens through which to evaluate new methods that seek to forge a more constructive relationship between science and society in environmental research. This is particularly significant given that existing evaluations of 'Mode 2' have not taken this approach. I finally address the growing body of literature in the field of engineering which seeks to realign the profession with the moral implications of its work, providing a further need to offer empirical insights into how engineers can work constructively with the public. This section is followed by an introduction to my case study, The Engineering Exchange, and it is through an evaluation of its work that I will explore the subsequent themes.

2.1 The 'Mode 2' thesis

In *Rethinking Science: Knowledge and the Public in an Age of Uncertainty* (2001)[3] Nowotny, Scott and Gibbons' argue that the process of research is being transformed. This thesis, often simplified to 'Mode 2' describes the shift from 'Mode 1' (theoretical, experimental science) to 'Mode 2' (trans-disciplinary, application-focused, socially responsive) research. According to Nowotny et al. expertise has become distributed throughout society, and as a result in this 'Mode 2' society the public now demands greater accountability and innovation from those who produce research (2001). These two related ideas I understand to draw on two key themes in STS literature: firstly, the demand for innovation in order to understand complex objects of environmental

[3] a development of their argument in *The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies* (1994).

research, and secondly the demand for accountability by changing the relationship between experts and policy makers.

The demand for innovation in research has occurred within the context of a changed approach to objects of scientific inquiry which are in part shaped by those who perceive them. Therefore the inclusion of multiple perspectives requires researchers to innovate in order to produce knowledge that is more culturally aware. The work of Bruno Latour has led the way in asserting that we can enhance research by deepening our understanding of the actors involved: *Science in Action* (1987) described how in following around scientists and engineers we can see that science, technology and society are continually co-produced by the synergy between humans, social relations, facts and theories. This analysis challenges a linear understanding of societal development (e.g. new technology leads to social change) arguing that networks of actors that interact to produce change in often unpredictable ways (Latour 1987). Latour's later work, *We Have Never Been Modern,* explains how society has come to accept the separation of science from politics and argues that we should overcome this separation through the acceptance that in our reliance on representations of objects these understandings are inevitably culturally embedded (Latour 1993). In accepting that politics shapes all of our understanding we are able to 'convene a Parliament of Things' that has a much improved chance of grappling with the 'messiness' of life' (1993: 145). Significant for this study is that Latour's work pre-empts new creative research methods that are no longer confined to a laboratory, are more experimental, and require practitioners to embrace a changed relationship between science and society.

The expectation of more accountable research is contextualised by the growing popularity of science-policy perspectives that critique the way science engages with society both through the constraints of its institutions and the methods of its practitioners (e.g. Functowitz and Raveetz 1993, Pielke 2007, Stilgoe 2009, Sarewitz 2011). A range of options are suggested for the reform of science: one way would be

for scientists to adapt the way they communicate their research so that it prepares the public for the degree of variability of results (Pielke 2007, Sarewitz 2011). Pielke argues that scientists should act as 'Honest Brokers' (2007) who present a range of policy options as a result of their research; likewise Sarewitz highlights the lack of transparency of consensus reports and calls for scientists to present dissenting evidence in their reports (2011). Alternatively, Functowitz and Raveetz argue that today's 'post-normal science' where facts are uncertain and the stakes are high must do away with reductive, disciplinary, peer review, and reform mechanisms of quality control so that more stakeholders can be involved (1993).

At the heart of these accounts is the ideal of democracy and the notion that in remembering these values scientists will be compelled to act more responsibly. Pielke's work *The Honest Broker* argues that the choices scientists have to make concerning how they position their research in relation to policy and politics will be shaped by their 'preconceptions about democracy' (Pielke 2007: 152). Stilgoe has echoed the emphasis on the burden of responsibility upon scientists to 'intertwine their work and their citizenship' (2009: 11) by acknowledging how their personalities and commitments can shape their practice. However, these accounts tend to rely on changing the mindsets of scientists so that they might become more socially responsible which is difficult to achieve by simply arguing for greater democracy. While highlighting the failings of science's engagement with society, little insight is offered into how the culture of scientific research can be more broadly changed. The notion of changing the mindsets of experts is something that will be explored later on in this study.

2.2 New language for research

The 'Mode 2' thesis argues that the growth in these contexts is generating a new culture of research that is both more experimental and more culturally aware, and that science has moved from the lab out into the *agora* (2001). In *Rethinking Science* Nowotny et al. describe norms that are alive in 'Mode 2' practice. Firstly 'contextualisation', which is

described to be the process whereby society and science interact in a greater number of locations [e.g universities, industry, think-tanks, consultancies] (Nowotny et al. 2001) As the two are integrated this leads to an expansion of the presence of 'people' in research producing greater social awareness in the process (ibid: 262) . The variety of circumstances in which research is produced has enabled science to take on a trans-disciplinary character. Secondly, new knowledge becomes 'socially robust' through a process of societal acceptance as opposed to scientific autonomy (2001). Finally, this changing culture of research is leading to a process of 'reverse communication' whereby the interaction of science with society is altering the core of how research is practiced (2001). The authors leave us with the challenge of defining the rules of this new culture of research to enable the increased base of public participation that it requires (2001: 262).

The 'Mode 2' thesis has been critiqued for failing to define the above ideals as normative concepts. For example, the authors fail to explain what exactly constitutes 'socially robust knowledge' throughout the text. Weingart argues that the notion of 'socially robust knowledge' can amount to little more than 'a property scientific knowledge should achieve' through opening itself up to 'context' (2008: 136) . In addition, 'contextualisation' should be inferred to mean 'social and political concerns, the values and interests of lay publics' (Weingart 2008: 137). Furthermore, Weingart points out the lack of temporal clarity about the shifting influence of 'socially robust knowledge' on the 'epistemological core' of science and argues that Nowotny et al. flit between presenting the question of what will affect 'contextualisation' and then asserting that it has already happened (Weingart 2008: 134). However, Weingart goes on to argue that the introduction of the appearance of 'socially robust knowledge' is symbolic of a change in debates around the democratisation of science and technology, as it acknowledges that it is preferable to include from the outset 'values and interests' in the process of producing new knowledge (Weingart 2008: 144).

A similar stance was adopted by Jasanoff (2003) who highlighted the practical problems of such conceptual innovation. She too understands the shift to 'socially robust knowledge' as a process whereby science gains strength through connecting its work to public ends (Jasanoff 2003: 235). However Jasanoff raises the question of how such a shift in knowledge production can be institutionalised, asking us how to 'promote more meaningful interaction among policy-makers, scientific experts, corporate producers, and the public' within our current unsympathetic structures (Jasanoff 2003). She raises the issue of new modes of knowledge production (Mode 2') where they lack normative direction, as attempts to conduct socially embedded science are happening within institutional structures that seek to separate science from values. She argues that participatory research should have clear aims and objectives if it is not to be tokenistic. This insight gives further rationale to my evaluation of 'Mode 2' methods in action.

Nowotny et al. responded to criticisms of 'Mode 2' in an issue of Minerva (2003) where they asserted that *Rethinking Science* was intended as a 'reflective essay' to support the development of a 'new language for research' as opposed to an 'empirical account' of society (Nowotny 2003: 186). In the same essay Nowotny refutes the claim that 'Mode 2' is a secondary activity, arguing for the need to investigate the ideas of this production of knowledge using social theory (2003: 192). Seemingly, the promise of 'Mode 2' is believed to have wider conceptual implications than has thus far been explored.

2.3 Evaluation of 'Mode 2'

The 'Mode 2' thesis has received particular attention in the field of environmental science where it has been argued that more empirical work is needed into the implications of these ideas for the inclusion of 'society' in research (Barry & Weszkalnys 2013, Whatmore 2009). Both Barry and Whatmore highlight the way in which trans-disciplinarity is a quality of research which is now expected by policy-makers and funders. Whatmore concludes that the 'political charge of the Mode 2 orthodoxy' strives

to recast research agendas in the service of society (2009: 589). Barry & Weszkalnys show that the transition towards 'contextualisation' has not been straightforward, as in many cases the integration of 'society' has happened through the inclusion of political representatives instead of publics (2013). One unresolved area that these authors point out is that the 'Mode 2' thesis overlooks the challenge of remaining autonomous and independent as 'societal interests' may politicize the research process (2013: 10). Alternatively, Whatmore highlights the challenge of continually mobilising publics that experts can collaborate with (2009: 596). Both these authors point to a continued role for the social scientist in informing the ongoing development of these research practices to better understand how to include 'society' in research (Whatmore 2009, Barry & Weszkalnys 2013), which is of particular significance to this study.

There is therefore a greater need to explore empirical examples of 'Mode 2' inspired research that evaluate their effectiveness as well as their implications for the changing culture of research. I agree with Prainsack's recent observation that despite all the assumptions[4] of collaborative research, evaluations of these methods have been restricted to 'narrowly framed research questions pointed only at the problem of how interdisciplinary research is accomplished' (Prainsack et al. 2017: 193). Deployment of the 'Mode 2' concept has been used to support the design of innovation in research programmes from interdisciplinary research centres (e.g. The Macaulay Centre and The Tyndall Centre for Climate Change Research) to science shop models of participatory research (see Irwin 1995). However just a handful a qualitative studies have been completed which evaluate these methods, and these have focused on completion of the research process as opposed to consideration through a 'Mode 2' lens.

Evaluation of these ideas in practice remains relatively limited and has focused on the soft-skills of researchers which are constructed as vital to successful collaboration. A

1. [4]interdisciplinary knowledge is better than disciplinary knowledge. 2. disciplines are silos that constrain interdisciplinary knowledge. 3. interdisciplinary interactions are unconstrained by status hierarchies (Parsaik et al. 2017: 408)

report by Tomkins that collates evaluations of interdisciplinary research centres emphasised the importance of soft skills to the success of interdisciplinary work such as being 'self-confident and interactive' (Tompkins et al. 2005). This echoed the earlier work of Bruce et al. (2004) which focused on the Interdisciplinary Fifth Framework Programme in Europe which emphasised the need for interdisciplinary workers who are 'open-minded and flexible'. These qualities were perceived to be important due to the language barriers that exist between disciplines. Boix-Mansilla's evaluation of interdisciplinary practice found that the achievement of acceptable forms of quality control required new 'procedural approaches' that were neither 'too local' nor 'too generic' (27: 2006). Personalities and effective social interaction have been found to have a critical impact on the success of these research processes (Bruce et al. 2004, Tomkins 2005, Mansilla 2006), although this is a focus of evaluation that will be challenged later on in this study.

A further realisation of the 'Mode 2' culture can be seen in studies of 'science shop' models, where community members make requests for research from experts (Irwin 1995: 162). A comparative case study of science shop models across Europe concluded that while each shop had developed mechanisms for mediating between citizen groups and public spheres, these took place in 'local niches' (Leydesdorff & Ward 2005; 366-67). The study argued that a new social contract between science and society will have to encompass a multitude of intellectual shapes and institutional formats' (ibid. 361). Again, however, this did not seek to evaluate these practices in light of the conceptual argument made in the 'Mode 2' thesis.

2.4 Recasting Engineers in Society

What I have written above indicates the significance of applying the 'Mode 2' concept to a case study of engineering research practice. I am focusing on The Engineering Exchange's work related to air quality as an example of collaborative engineering

research which will contribute some empirical work to a discipline lacking familiarity with participatory methods.

While STS scholars acknowledge both scientists and engineers in their critique of experts, literature related to the sociology of engineering seeks to separate engineers from scientists while still attempting to recast the profession in the service of humanity (Riley 2008, Baille and Catalano 2009, Poser 2013, Michelfelder et al. 2013). Engineers have been distinguished from scientists on the basis that the problem-solving approach of engineers places them closer to the 'end-use' and therefore to the publics they serve (Riley 2008, Baille and Catalano 2009, Poser 2013, Michelfelder 2013). Despite the idea that engineers are better placed than scientists to contend with politics, the literature showed a more traditional understanding of the role of expertise amongst its practitioners. Riley, a proponent of more 'socially just' engineering, has argued that empowering communities to engage with technical issues requires consideration of the 'power dynamics around the 'cult of the expert'' (2008:109). Explorations of the involvement of engineering in matters of social justice observe that the profession has traditionally not been able to deal well with 'lay-audiences' (Riley 2008, Baille and Catalano 2009). So although it is argued that engineers are well placed to respond to societal demands through their problem-solving approach, this is yet to be evidenced through empirical work.

In summary, existing qualitative work on 'Mode 2' inspired research has focused on its ability to produce robust outcomes and do not address this work in light of its implications for the inclusion of 'society' in research and the redistribution of expertise. I will show that by focusing on the personal experiences of 'Mode 2' practice I am better able to explore the wider impacts of these methods and the processes of 'contextualisation', 'reverse communication' and production of 'socially robust knowledge' (Nowotny et al. 2001). This study will also be the first to apply qualitative methods to a case of upstream engagement in engineering research, exploring the potential for experimental engineering research to contribute to the solving of

environmental problems. Finally, through the insights that this work provides it is hoped that this can support The Engineering Exchange to develop its practices for the ongoing success of its work. The next section will introduce my case study in more detail.

3. A case study: The Engineering Exchange

The work of The Engineering Exchange began in the context of a growing culture of public engagement at UCL. These efforts now have their own dedicated resource, the UCL Public Engagement Unit, which pursues 'publicly visible impacts' for the universities' research and ensures that it has a 'voice in matters of concern' in London (UCL Public Engagement Unit, website). The Unit strives to embed a culture of public engagement across the university, which is described as central to ensuring UCL can continue to: 'transform how the world is understood, how knowledge is created and shared, and how complex problems are solved' through 'collaboration, partnership and dialogue' (UCL Public Engagement Unit, website). The Public Engagement Unit therefore supports the university in conducting research that raises the university's profile and involves external participation (e.g. the Bright Club and Creating Change).

3.1 Aims of The Engineering Exchange

As a participatory initiative, The Engineering Exchange defines its mission to be 'to make UCL Engineering expertise available to communities, while helping staff & students align their work with local needs' (Engineering Exchange, website). They understand community engagement to be a two-way process in that it both enables community groups to access academic research and engineering expertise, while better aligning the work of academics and students to community needs.

The work of The Engineering Exchange is centred on the achievement of the following key aims:

"Research: aligning engineering research with community needs.
The EngEx supports researchers in developing community based research projects and in working with communities to turn a specific need for technical knowledge into an appropriate research question and project. The EngEx supports researchers to incorporate upstream public engagement in their projects to better address the need for responsible, responsive research and innovation."

"Skills: providing communities with access to engineering skills and knowledge.
The EngEx provides a brokering service to match specific community needs for technical expertise with staff and students in UCL Engineering. For instance, communities may have needs for environmental monitoring, mapping or support in developing local sustainability plans."

(The Engineering Exchange Annual Report, 2015).

In practice this involves brokering engineers with community participants so that they can collaborate to tackle 'problems related to technology, infrastructure and the environment' (Engineering Exchange Website). The Engineering Exchange responds to requests for their service of match-making the two groups, and provides tools to support them in working together. In addition, they have hosted a number of Community Research Forums in an attempt to spark ideas for new collaborative projects. These were attended by a wide array of stakeholders who were asked to work in teams and come up with new ideas for projects. The Engineering Exchange has also organised a number of Professional Development courses for engineers to help them to work with community groups. This element of their work, however, has not been explored through this research.

3.2 Engineering Exchange projects related to Air Quality

This dissertation focuses only on the Engineering Exchange's projects related to the issue of air quality and reducing pollution. An overview of these projects is listed below.

Project name	Overview
Old Street Roundabout Air Quality	Research project to establish delivery patterns in Old Street area to evaluate feasibility for a freight consolidation centre that would reduce the number of trips by polluting freight vehicles
Regent's Park Estate air quality	Empower local community to measure air quality and understand how it relates to acceptable levels of pollution
Barging around London	A feasibility study into a canal freight vessel that provides an alternative to mass transport
Pollution Air Reduction Project	Develop/optimise a design for a freely available, low cost self-built water doping system (a vehicle retrofit) to help reduce pollution in London and globally.
Improving Crossrail impacts on Bentham House Community	Initiative to improve communication from Crossrail and review of available data on noise and air pollution
No to Silvertown Tunnel	Submit comments on planning application to ensure they are scientifically rigorous

Oxypod	Development of an experiment to test this device which improves the efficiency of heating systems

Table 1. Summary of Engineering Exchange projects included in evaluation

3.3 Engineering Exchange as ‘Mode 2’

The work of the Engineering Exchange was chosen as a case study because it can be identified as an empirical example of ‘Mode 2’ inspired research in order to address issues of sustainability. Its mission reflects the two related consequences of the redistribution of expertise in society. Firstly, its aim to work with communities to develop projects that match local knowledge with technical support reflects the need to combine diverse perspectives and create new methodologies in order to address trans-disciplinary objects of research. Secondly, its intention to influence the academic research agenda towards more problem-focused research exemplifies the imperative to increase opportunities for public participation in order to improve the accountability of UCL to the public that it serves. Therefore, through an evaluation of its activities through a ‘Mode 2’ lens, this dissertation will both add to conceptual debates whilst offering practical insights for ways in which the project could be improved.

Source: Regent's Canal taken from the Engineering Exchange Annual Report 2015

4. Methodology

In a subsequent essay to the publication of *Re Thinking Science* Nowotny et al. ask us to 'systematically explore the implications of these ideas for systems and institutions in general' (Nowotny 2003: 192) and so in evaluating the success of The Engineering Exchange's air quality projects this will provide empirical work related to this cause.

Distinctively, The Engineering Exchange is an example of 'Mode 2' research that focuses on community engagement; therefore this dissertation will include comparison and analysis of the accounts of engineers and members of the public who were engaged by the project. Furthermore, the 'Mode 2' ideals of 'contextualisation', 'socially robust knowledge' and 'reverse communication' (2001) will be considered throughout my analysis. As explained in the literature review, while some research exists that

evaluates ‘Mode 2’ in practice, this has focused on the sites of knowledge production by asking participants about the successes of trans-disciplinary collaboration and how this affected the research outputs produced (e.g. Boix-Mansilla, Tompkins, Bruce et al.). Furthermore, previous studies have focused on interviewing academics only, which differentiates them from this work (ibid).

4.1 Data generation

My fieldwork consisted of a combination of document analysis and participant interviews of those who had been involved in relevant projects. As a researcher I was aware that I was not approaching my case study from a position of disinterest and therefore I should remain mindful of my ‘standpoint’ (May & Perry 2014:4): I was viewing The Engineering Exchange with knowledge of the aspirations behind the initiative and intentions of its founder.

4.1.1 Document analysis

I began my data generation by collating the documents produced by The Engineering Exchange, which I collected via a Dropbox account which staff granted me access to. I identified the key documents that were most relevant to my research as: The Engineering Exchange Annual Report, Protocols (x3), Project Scoping Documents (x7), Project Outputs (x3) and Engineering Exchange Write-ups (x5). Through these documents I intended both to gain an understanding of how the initiative practiced ‘Mode 2’ research, and highlight any assumptions about the two participant groups.

4.1.2 Semi-structured Interviews

As my primary aim is to capture the experience of participants who have engaged with The Engineering Exchange, I believed interviews to be the most suitable method for my research. The aim of an interview is ‘to understand how individual people experience

and make sense of their own lives' (199:111) which here would enable me to understand the experience of participation. I therefore conducted seventeen semi-structured interviews with a mixture of engineers, community members and staff, with a reasonable balance between the engineers and community participants. These interviews were conducted in locations of my participants choosing, and lasted between 45 minutes to 1 hour 15 minutes. My participants were recruited through my relationship with the Project Manager of the Engineering Exchange, who in this instance was the 'gatekeeper' (Valentine 1997) through which I gained access to project participants via email introductions. Although my participants fell into three broad categories: engineers (5), community member (8), staff (3), these represent a simplification of the diversity of individuals involved. Not all the academics were from an engineering background (2x environmental science) and community participants came from a range of backgrounds (such as consultancy, business and social enterprise). All interviews were arranged via email correspondence between myself and the participants, all of which had a minimum of one face-to-face engagement with The Engineering Exchange initiative. The below table shows a list of the interviews conducted.

Date	**Interviewee**	**EngEx Project**	**Category**
14.06.17	Giles	Canal Freight	Engineer
19.06.17	Gesmay	Air Quality Monitoring	Community
20.06.17	Ben	Air Quality Forum	Community
20.06.17	Samantha		Staff
23.06.17	Ben	Air Quality Forum	Engineer

23.06.17	Andrea	Old Street Air Quality Monitoring	Community
26.06.17	Sean	Air Quality Forum	Community
28.06.17	Del	Canal Freight	Community
29.06.17	Clive	Air Quality Forum	Engineer
30.06.17	Bob	Oxypod	Community
01.07.17	Alan	Vehicle Engine Retrofit	Community
10.07.17	Paul	Vehicle Engine Retrofit	Engineer
13.07.17	Muki	Air Quality Monitoring	Engineer
13.07.17	Sharon	Air Quality Forum	Community
11.08.17	Sarah		Staff
18.08.17	Charlotte		Staff

Table 2. List of interview participants and interview dates

I expected all my participants to be willing to participate in the interview format in the context of an 'interview society' where people are used to providing their opinions alongside experiential information (Gubrium & Holstein 2001: 3). The first part of my interview was designed to elicit narratives from my participants drawing on the 'psycho-social' approach of Jefferson and Holloway (2011) with the hope that this would allow

me to understand the social dynamics of participating in The Engineering Exchange. Key to the success of this approach was effective listening skills as narrative interview approaches require that the interviewer 'must be a good listener and the interviewee is a story-teller rather than a respondent' (Jefferson and Holloway 2011: 8). Through drawing on such 'confessional properties' (Paul Atkinson and Silverman 1997: 12) of the interview this encouraged my interviewees to express personalised accounts of their involvement with The Exchange. By taking this approach I hoped to co-produce data with my interviewees in a way that was sensitive to socio-political and cultural dynamics. I remained aware that a risk in my approach would be the interview going off topic as participants were invited to tell stories in their own ways.

The semi-structured approach was conducted using an interview schedule as a prompting device to ensure that my interviews maintained a high degree of consistency across all the categories of participants (see Appendix 5). The narrative element of the interview was followed by a series of more focused questions around specific themes. I recorded each interview using a Dictaphone and added my own notes about the experience in a research diary.

4.2 Data Analysis

In order to prepare my interview data for analysis, the audio files were transcribed by hand which allowed me to become familiar with the data I had generated. I then analysed this data using an iterative process in an attempt to remain open to what I might find so that my evaluation was reflexive in its approach. A process of 'emic' and 'etic' coding was used to develop themes for my analysis. The process of etic coding was key as in order to consider the case of The Engineering Exchange in light of the 'Mode 2' thesis, a focus on the etic descriptions would link my data to this social science perspective (Given 2008).

4.3 Confidentiality

All participants signed a consent form allowing for quotations to be used anonymously in my thesis. Therefore participants are referred to throughout the analysis using the labels ‘Community Participant’, ‘UCL Engineer’ and ‘Staff’, as this enables comparisons between the perspectives of the two groups, while not revealing their individual identities.

5. Data analysis and discussion

The following sections of analysis explore the effectiveness of The Engineering Exchange as ‘Mode 2’ research, through analysis of both the project documentation and participant accounts of the process. The first section considers the success of the projects in achieving their outcomes, and considers their implications for how research becomes ‘contextualised’. The second section analyses the role of ‘expertise’ amongst participants of the project. The final two sections consider the wider impacts of the project for both participants and for continuing use of ‘Mode 2’ research.

5.1 ‘Contextualising’ engineering research

While The Engineering Exchange successfully brought together multiple perspectives related to the problem of air quality through understandings from both the community and engineers, this did not always lead to the successful completion of a project. Projects were most successful where they related to developing an ‘end-use’ technology and therefore the engineers remained closer to the practice of the engineering discipline (Michelfelder et al. 2013). Furthermore, it was found that projects that responded more directly to political agendas did not progress, showing that as Barry & Weszkalnys (2013) have argued, ‘contextualised’ research can be vulnerable to the appropriation of political interests, which in this case stifled their success.

Integrating multiple perspectives around the issue of air quality led to the design of research projects driven by their 'context'. Both community participants and engineers related to the issue of air quality in varied ways, and as a result these understandings led to a variety of different projects (as listed in section 3.2). The community participants more commonly referred to the health impacts of the issue, which is evidence of how including 'people' in the research process can make it more 'socially aware' (Nowotny et al. 2001: 262).

"That's a problem that keeps on emerging and mutating in different ways. It's public health, its chemistry about the actual pollutants and measuring them."

UCL Engineer, Interview

"Although outdoor pollution is a big issue, including the air coming from the outside in, there are also tons of indoor sources"

UCL Engineer, interview

"I'm interested [in air quality] because I have children. I'm affected, they're affected"

Community participant, interview

"Right now I'm scared because I don't know how many chemicals there is in my lung"

Community participant, interview

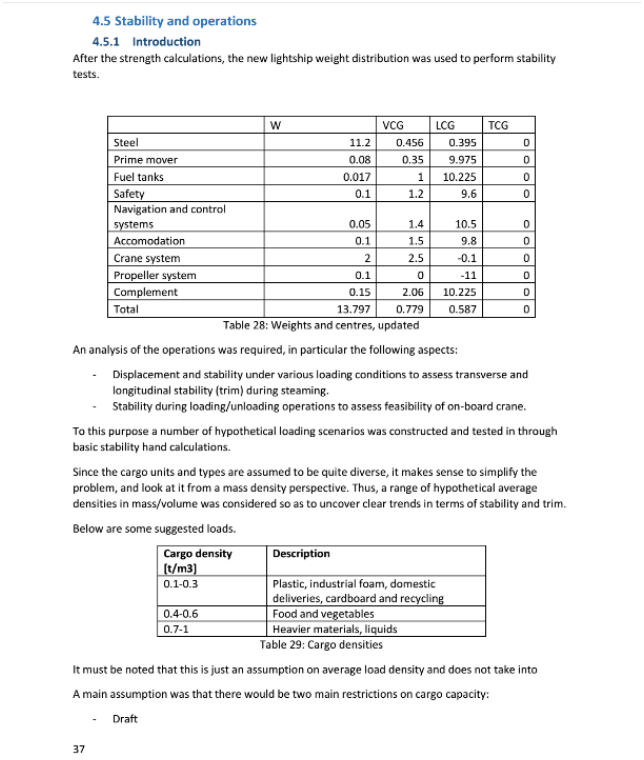
Through a ‘Mode 2’ lens, community participants can be understood to be in pursuit of ‘new social innovation’ in The Engineering Exchange (2001: 250) as they felt that their concerns were not being addressed through other societal mechanisms. However, the subsequent projects that were initiated achieved a mixed record of success with some of them failing to progress past the conceptualisation stage. According to The Engineering Exchange, *‘Projects are considered successfully completed when the objectives are met and stakeholders have held a final meeting to offer feedback and “close out”’* (Engineering Exchange, Annual Review 2015). Yet in the absence of recorded evidence of ‘close out’ interviews, successful projects were determined by the existence of a research output, which were then verified by participant interviews. Table 3 illustrates the variety of projects and whether or not they were completed.

Project Aim	**Project Status**
Barging Around London: design of cutting edge canal freight vessel	Complete
Oxypod: devising an experiment to prove Oxypod removes oxygen from water in heating system	Complete
Pollution in Air Reduction Project: test the principles of a water doping device	Complete
Improving Crossrail Impacts on Bentham House Community: a review of the evidence	Incomplete

Old Street Freight Vehicle Reduction: evaluate the viability of freight consolidation centre to reduce number of trips by polluting freight vehicles	Incomplete
Silverton Tunnel application evaluation	Incomplete
Regent's Park Estate Air Quality: empowering local community to monitor air pollution	Partially complete

Table 3. List of projects and their status

Where the projects aims were to produce specific technical reports relating to an idea brought forward by an individual community member, the project outputs were found successfully completed. These successes were then verified through the interviews I conducted in which both the engineer and community participant spoke very highly of their engagement with one another, and were satisfied with the research outputs produced.



4.5 Stability and operations

4.5.1 Introduction

After the strength calculations, the new lightship weight distribution was used to perform stability tests.

	W	VCG	LCG	TCG
Steel	11.2	0.456	0.395	0
Prime mover	0.08	0.35	9.975	0
Fuel tanks	0.017	1	10.225	0
Safety	0.1	1.2	9.6	0
Navigation and control systems	0.05	1.4	10.5	0
Accomodation	0.1	1.5	9.8	0
Crane system	2	2.5	-0.1	0
Propeller system	0.1	0	-11	0
Complement	0.15	2.06	10.225	0
Total	13.797	0.779	0.587	0

Table 28: Weights and centres, updated

An analysis of the operations was required, in particular the following aspects:

- Displacement and stability under various loading conditions to assess transverse and longitudinal stability (trim) during steaming.
- Stability during loading/unloading operations to assess feasibility of on-board crane.

To this purpose a number of hypothetical loading scenarios was constructed and tested in through basic stability hand calculations.

Since the cargo units and types are assumed to be quite diverse, it makes sense to simplify the problem, and look at it from a mass density perspective. Thus, a range of hypothetical average densities in mass/volume was considered so as to uncover clear trends in terms of stability and trim.

Below are some suggested loads.

Cargo density [t/m3]	**Description**
0.1-0.3	Plastic, industrial foam, domestic deliveries, cardboard and recycling
0.4-0.6	Food and vegetables
0.7-1	Heavier materials, liquids

Table 29: Cargo densities

It must be noted that this is just an assumption on average load density and does not take into

A main assumption was that there would be two main restrictions on cargo capacity:

- Draft

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Source: Excerpt from ‘Barging Around London’ Project Output: Feasibility study of canal freight vessel

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“I got a good report… very useful”

Community participant, interview

Project Background

Briefly describe the problem that the project will address.

Diesel Pollution is linked to many deaths in London and elsewhere. Nano particles and other pollutants are caused by the combustion process. Nano particles stay airborne around the world until ingested by something (lungs).

Improving combustion efficiency leads to reduced pollution, e.g. if less fuel is burned then less pollution is produced.

- LPG/CNG or Hydrogen over diesel is a known entity for improving combustion rates.
- Water mist is known to have positive effects on charge cooling/density leading to improved efficiency.
- Steam is known to clean engine combustion chamber internals restoring efficiency and is also used to help clean clogged DPFs.

It is possible to derive these properties from a novel water doping system.

Anecdotal test results from real world driving conditions suggests that these principles have a real effect on pollution produced while driving

Project Aims/Objectives

Detail the overall aims/objectives of the project. This should be one or more short statements that capture exactly what the project needs to accomplish (e.g. create a system for housing associations to assess the case for demolition or refurbishment of their estate).

The Overall objective is to prove the principles of water doping in London based on realistic mobile operating conditions, to provide evidence for the adoption of water doping to reduce London pollution. But there are many steps that can be taken in the laboratory with UCL before undertaking such tests:

Determine the constituent properties and effects of the product gases and mist from a water doping system and their effects on combustion.

Analyse the water doping device materials that enable the chemical reaction to produce a synthetic gas. (One set of materials test results already exist, suggesting the possibility of the system enabling a Sabatier reaction).

Assess whether it is possible to create the water doping reactive effect from commonly available low cost materials e.g. coins etc.

Explore the sources of electrostatic charge and consequential electrostatic effects on the water doping system, inlet charge and combustion.

Explore the effects of water doping on construction plant equipment operating in London.

Develop/optimise a design for a freely available, low cost, self build, water doping system, to help reduce pollution in London and globally. Thus avoiding the constraints associated with market pressures and supply line limitations, leading to a more immediate opportunity to cut pollution cheaply globally.

Source: Extract from Pollution in Air Reduction Project (PARP) Project Scoping Document

Where a project scope did not involve the testing of a specific technology and was driven by a more overtly political agenda, the projects had not moved beyond the conceptualisation stage. Commonly, these were focused around mobilising a community to compile evidence relating to air quality in response to a new development happening, or to supplement evidence put forward by professional bodies (e.g. TFL) that might be viewed as inadequate.

Political motivation	Objectives not achieved
Crossrail development's impact on Bentham House	A review of Crossrail's area plan to flag up any environmental justice issues
Impact of HS2 on Regent's Park Estate	Community literature review and long term air quality monitoring plan
Impact of TFL's Silvertown Tunnel Development	Report to challenge plans to build Silverton Tunnel
Reducing air pollution in the Old Street Area	Report which evaluates viability of a freight consolidation centre to reduce air pollution

Table 4. List of project objectives categorised by success

In the absence of project outputs or written updates of project challenges, interviews with participants were vital in understanding why these projects did not move past the initial phase. Through emic coding it was determined that the failed development of these projects was attributed to lack of resources; time, money and people in differing proportions.

"We hadn't managed to access a pot of money to actually take it off."

UCL Academic, interview

"No one really had the time and money to actually own it."

Community participant, interview

So while the air quality related project ideas were evidence of how bringing together multiple perspectives can drive problem-focused research, these were not always deliverable by the actors involved. While 'Mode 2' research is expectant of research teams that can contend with the trans-disciplinary objects involved (Nowotny et al. 2001), in this case attempts to deviate too far from the engineering discipline were unsuccessful. Given engineers familiarity with the 'end-use' of problem-solving technologies (Baille and Catalano 2009, Poser 2013, Michelfelder 2013), perhaps it is unsurprising that projects that would have expected them to engage directly with issues outside of technological development were not successful.

In addition, although the participants related the project failures to lack of resources, at an etic level this is suggestive of the need to demarcate research that is 'socially aware' from becoming too heavily encroached upon by politics (Barry & Weszkalnys 2013) as the extra resources needed to mobilise the community could not be met by the initiative. Furthermore, as per Barry & Weszkalnys argument (2013), I believe that for the researchers involved, delivering such 'contextualised' research outputs while remaining unbiased would have been challenging (e.g. research designed to dispute evidence provided by TFL or HS2). This case shows that the process of 'contextualisation' should not be used to draw researchers too far from their disciplinary training for political gains. Unsuccessful projects show that the expectation of engineers to mobilise a community group proved too ambitious within the remit of the initiative. Of course it is not possible to know what the successes of these projects might have been had more resources available.

5.2 Towards more ‘Socially Robust’ knowledge

Both engineers and community participants attributed the success of their engagement with The Engineering Exchange around the idea of gaining ‘credibility’. Therefore a changed understanding of expertise was observed in both participant groups. Experiences of participants found power dynamics between ‘experts’ and ‘publics’ to have minimal significance to the ways in which individuals engaged and is suggestive of a mutual acknowledgement of the need to generate ‘socially robust knowledge’ (Nowotny et al. 2001). Furthermore, this highlights that future evaluation of ‘Mode 2’ research should lessen its focus on the soft-skills of researchers as this wrongly assumes the process of collaboration in itself to be challenge.

The Engineering Exchange conceptualised itself around the notion of expertise as ‘technical and scientific knowledge’ that is usually inaccessible to the community (Engineering Exchange, Staff and Client Protocols). According to the documentation produced by the project, the central offering of The Exchange is its provision of ‘expertise’ to those who did not previously possess it. It has produced practical guidelines upon which to base its projects in the form of Partnership Protocols; a set of guidelines for UCL Engineers, and another for a Community-based ‘client’. This terminology is used, according the project’s founder, so that the model mirrors the way of working with any other external partner: *‘We try to run it on the same lines as far as possible’* (Founder of Engineering Exchange, interview). Both Protocols also state that through the improvement of ‘*knowledge of technical issues*’ this should be intended to *‘contribute to a better quality of life*’ (ibid.).

Despite the innovative potential of The Engineering Exchange, its protocols reflect the assumption that expertise is stored within the University as opposed to being socially distributed. This is evidenced by two key differences which were observed between the documents. Firstly, that the Protocol aimed at the Engineers states a further aim to *‘support UCL Engineering Staff and students to align their work with local community*

needs' (EngEx Engineer Protocol) while the Client Protocol provides no mention of this. Secondly, the Client Protocol asserts that '*We don't have expertise for projects that are focused mainly on social or political issues. Our work is focussed on science, technology and engineering*' (EngEx Client Protocol). These differences reflect an assumption that the two groups would have different understandings and motivations for participating.

However the participant's accounts from both groups showed that achieving accountability was believed to be a successful outcome for all, with the idea of 'expertise' being notably absent from their narratives of the process. At an emic level, all categories of interview participant referred to the idea of 'credibility' as something that the projects could achieve. Neither believed success to be related to the specific benefits of scientific and technical knowledge. Through a 'Mode 2' lens, this mirrors Nowotny et al.'s (2001) rejection of the importance of 'belonging' to a 'lay-expert' community in 'Mode 2' society,as now the significance of new knowledge is dependent on more complicated social arrangements.

"I thought it will make my case more credible, and not only that it will make me feel more valued, it will make me more confident"

Community participant, interview

"He wants credibility in some way"

UCL Engineer, interview

"Definitely the credibility thing does come up a lot."

Manager Engineering Exchange

At an etic level this can be interpreted as the acceptance that achieving accountability is now understood by both participant groups as a social activity as opposed to a purely scientific one. Through the lens of 'Mode 2' this is evidence of a shift towards 'socially robust knowledge' (2001) in that participants were acutely aware of the demands of the social context in which their ideas were present. The intention of the community participants to secure trust in their ideas seemed more closely related to the reputation of UCL as an established authority, as opposed to the gaining of the 'mechanical objectivity' associated with scientific expertise. This demonstrates the belief of participants that the possession of expertise alone , without the mechanism to secure trust in this content, will have little impact in society.

"Having credible evidence from an irrefutable body is of value."

Community Participant, interview

"TFL are more likely to pay attention to people like the Engineering Exchange and UCL than people like me."

Community Participant, interview

Frustrations therefore arose amongst participants when the next steps for gaining wider buy-in to their 'socially robust knowledge' remained challenging. For example, the 'Barging Around London' Project's evidence for the viability of using canal freight

vessels was not able to generate interest from Transport for London. As per Weingart's criticism (2008) of 'Mode 2', if we attach expectation to a normative concept of 'socially robust knowledge' this will leave us disappointed as it is not something that can be achieved through simply opening up knowledge creation to the 'context'. Although the research produced was accountable to public problems, the route to influencing policy remains complex and requires attention to wider power dynamics.

"It's a bit frustrating because the people you think would be most interested, TFL, they are just impossible to work with. They don't have anyone in charge of water aspects"

UCL Engineer, interview

However, I believe these to be signs of an acknowledgement amongst both the engineers and the community that 'socially robust knowledge' is now important in a descriptive sense. At least in the way that an integration of social values and interests should normalised throughout the process of knowledge production (Weingart 2008, Jasanoff 2003). In the case of The Engineering Exchange, the focus on credibility undermined any sense of hierarchy between participants, showing evidence of mutual respect for one another's perspectives. This was reinforced by both engineers and community members speaking positively of the experience of working collaboratively, using words to describe one another such as; '*brilliant*', '*excellent*' and '*passionate'.* Therefore, the positive understanding of participant experience provides empirical evidence that the idea of producing 'socially robust knowledge' has been accepted by both the 'expert' and the 'lay community'.

Furthermore, common understandings of success undermined the notion that the challenge of integration should be a focus of social science evaluation (e.g. Bruce et al. 2004, Tomkins 2005, Mansilla 2006). Engineers and community participants had mutual understanding of the reasons for their collaboration which in this case enabled them to work together with ease. In addition, although it is not possible to understand through this study how such new knowledge could better influence wider societal actors it has value in highlighting some specific policy areas which are in need of becoming more 'socially robust' (here TFL is suggested).

5.3 Facilitating 'reverse communication'

Whilst the above considers the successes of the process of The Engineering Exchange in delivering its project outputs, this section explores what wider impact the project might have had on participants. While my interviews were limited in providing evidence of changed mindsets, the engineers did show a willingness to have their mindsets changed through experience. I argue that this case provides empirical evidence for the importance of The Engineering Exchange in providing novel ways of working that have the potential to start a process of 'reverse communication' here at UCL (2001).

Through encouraging participants to offer narratives of their engagement with the project, this study moved beyond 'narrowly framed research questions' that tell us only about how such research is accomplished (Prainsack et al. 2017: 193). By allowing the interviewee to become a 'story-teller rather than a respondent' (Jeferson and Holloway 2011: 8) it was hoped that these stories would remain 'closer to actual life-events than methods that elicit explanations' (Gubrium et al. 2012: 9). The initial intention of this approach was to compare the ways in which engineers and community members related to the project. The themes that emerged, however, were not distinct to the two categories but appeared amongst both.

At an emic level interviewees accounts highlighted that for participants The Engineering Exchange achieved a wider impact through creating the opportunities for new 'ideas' to form.

"It's those kinds of connections that spark ideas and that's the whole idea of The Engineering Exchange."

Community Participant, interview

"As with many academics, we would tend to have many projects that are ideas and they only turn into real projects if just generally everything lines up… So in that sense I think The Engineering Exchange could generate ideas, and those could turn into projects."

UCL Engineer, interview

"Let's say this idea was in my archive, but then at the event [of The Engineering Exchange] I thought this is something I can present."

Community participant, interview

"Students gained from having Del [Community participant] to bounce ideas off"

UCL Engineer, interview

Despite not all the ideas that participants spoke of being successfully realised, it was believed that the collaboration involved in Engineering Exchange projects provided an often missing spark in achieving innovation. This was illustrated further by the ways in

which participants spoke about the importance of opportunities to create new connections.

"That is where things like The Engineering Exchange, without it being overtly political at all has recognised the need to actually do something and when you get that together with the academic side and the grassroots side and people with real issues that's where you might actually start to see change."

UCL Engineer, interview

"To find solutions you have to have a solid plan because it's not about you it's not about me, it's about a combination of people"

Community participant, interview

"It has created connections between me and the local community."

UCL Engineer, interview

"It was very participatory, all sorts of people were there… and we had a range of difference interests around the table so we were all contributing different things."

Community participant, interview

Through a ‘Mode 2’ lens, we see that both engineers and community participants valued the creation of opportunities for ‘contextualisation’ that brought together people in new ways. In fact, for most participants there seemed to be an assumption that this way of coming up with ideas was ‘better’ than ordinary research methods. Interestingly, as evidenced by the project documentation, this was not always matched by project success, highlighting again how the ideals of the ‘Mode 2’ thesis are not always borne out in terms of practical achievements.

Although it was in fact difficult to determine personal impacts on engineers, their accounts highlighted a willingness to have their attitudes changed through experience. A number of engineers indicated that they while they were not new to collaboration; they were new to collaborating with community stakeholders. This suggests that the project was likely to have had some impact in how they would perceive working with community stakeholders in the future.

“The difference here is that this was much more about the community, so working with people outside the university I’m relatively used to, but working with the community that was a new thing.”

UCL Engineer, interview

“We work with industry but we pretty much stay away from the public most of the time which is a bad thing because you know we’re trying to address their concerns and improve their quality of life.”

UCL Engineer, interview

“Community groups are really good at defining some of these problems. Probably too often industry takes a commercial viewpoint and the community is thinking from a totally different perspective”

UCL Engineer, interview

At an etic level this reflects how the engineers understanding of their practice was altered through their participation in this initiative. As the above interview excerpts show, the engineering research agenda is more commonly influenced by industry, so providing access to other options is valuable. This point becomes particularly interesting when considering the importance of changing the mindsets of ‘experts’ (Pielke 2007, Stilgoe 2009) to enable a more healthy relationship between expertise and policy. As addressed in the literature review, the notion of more socially responsible experts is desirable when thinking about a changed relationship for science and society (Pielke 2007, Stilgoe 2009). However, despite much being written about the need to use democratic values more broadly in research (Functowitz and Raveetz 1993, Pielke 2007, Stilgoe 2009) this case was found to be novel to the engineers at UCL. The Engineering Exchange can therefore be understood to represent a new and significant space where a process of ‘reverse communication’ (Nowotny et al. 2001) might begin.

Of course it is impossible to isolate the degree to which the perspectives of engineers were shaped by involvement with The Engineering Exchange alone. This reflects a criticism of the ‘Mode 2’ argument which states that the temporal dimension of ‘contextualisation’ is unclear (Weingart 2008). Nonetheless creating novel opportunities to participate remains crucial to driving such a process of ‘reverse communication’. As the Founder of the Engineering Exchange responded when asked what she had learnt so far from the process:

“One thing that has been nice to learn is that people really like this idea, which has been maybe a bit of a surprise. So that approach of giving people opportunities to engage rather than criticising them for not.”

Engineering Exchange Founder, interview

5.4 Recommendations for ‘Mode 2’ research

Finally, this chapter considers how focusing on a case study of ‘Mode 2’ engineering research makes it possible to make recommendations for the Engineering Exchange that are relevant to ‘Mode 2’ research more broadly. Following the completion of the interview process it seemed that there were two key areas for improvement in the way The Engineering Exchange initiates research projects. Firstly, a need was identified to more clearly communicate its mandate to community participants, and secondly that it could benefit from communicating its existence more widely to the public. Finally, this case shows that further empirical work is needed into how institutions facilitate ‘Mode 2’ research so that they can remain attentive to power dynamics.

All participants were asked to sum up The Engineering Exchange in a sentence, which at an etic level suggested that the engineers had a much clearer understanding of the concept behind The Exchange. In many cases these explanations had embedded within them an assumption of the moral reasons for participating.

“It’s a way of bringing together academics from UCL and the community because that doesn’t normally happen, there isn’t really a mechanism for that happening otherwise”

UCL Engineering, interview

“It’s a platform for community engagement with the local community organised by the Engineering faculty. I don’t think its exclusive to the engineering faculty but its useful to have a hub that does connect to the community in a formal way.”

UCL Engineer, interview

“Trying to mobilise that connection between engineering expertise and mainly university-based people at the moment, they have aspirations to get industry people involved too. To provide expertise to community groups who need that but would not ordinarily know where to get that.”

UCL Engineer, interview

“There is certainly some good moral reason for doing it”

UCL Engineer, interview

In comparison, none of the community participants interviewed were able to offer a clear definition of The Engineering Exchange and for some this had caused confusion around what to expect from their engagement.

“For the people behind it, is it an experiment? There are lots of projects going on, what are the successes, I don’t know. They are not telling us their goal.”

Community participant, interview

“So I don’t know much about The Engineering Exchange except it seems to be very well established… in a way it would be good if they decided… you know we’re getting all this information together but nothing sort of comes of it.”

Community participant, interview

“So for me the primary thing that it did was give us access to a standard of good quality academics… it would have been very difficult to achieve.. that’s all I know.”

Community participant, interview

These responses show that The Engineering Exchange needs to more clearly define the aims of the initiative to the public. Where participants felt that their expectations of the project had not been met, this was related to their lack of understanding of the purpose of the initiative. At an etic level this is evidence that there still exist challenges of communication in the process of integrating science and society through ‘Mode 2’ research. For the UCL staff involved there appeared to be an assumed social dimension of their involvement which is evidence of these methods being laden with moral implications for those who are academically trained. However these ideals were not understood by community participants, suggesting that the incentives for public participation were different. These differing incentives may account for the fact that the while ‘Mode 2’ impetus has driven a range of research agendas, public incentives are more likely to be driven by context-specific circumstances. In the literature, these difficulties have been attributed to the absence of a universal framework for research that successfully integrates ‘society’ into research processes (Whatmore 2009, Barry & Weszkalnys 2013).However, in the case of The Engineering Exchange it seems that such a challenge may have been helped through simply improving communication.

Secondly, despite the ease with which participants worked together, engaging in ‘Mode 2’ research did not entirely negate assumptions about the dynamics between experts and publics. I asked the Engineering Exchange’s Project Manager about whether she felt that her communication with community groups and engineers differed in any way and she spoke about how her role had enabled her to overcome certain assumptions about expertise.

“I think there would maybe have been an assumption on my part about the level of comprehension and the level that I pitched at. I probably thought that things needed to be delivered in a simpler way for community groups, but I was swiftly disproved of that notion. One of the interesting processes for me as part of this role has been the awareness on the part of the community groups about a lot of the issues and when they come to us they often have a very well developed idea about what they need and they’re actually a lot more knowledgeable than me on a lot of the issues, especially some of the politics around some of the issues. So I’ve had to rethink how I express the idea of expertise. So it’s much more similar now the way I communicate with both the groups. In particular the way I use the word expert and expertise, I’ve sort of changed it now so that its much more inclusive.”

Manager, Engineering Exchange, interview

This reinforces the earlier argument about how a shifting focus towards ‘socially robust knowledge’ implies that ‘Mode 2’ research does enable the concept of expertise to be rethought. However we should not assume that this means that understanding power dynamics are no longer important. When all participants were asked about how they

thought the Engineering Exchange could improve its impact the most common suggestion across all participants was that the project needed to reach out to more community groups in London.

“The only question is, are enough community groups getting the message that this is available? It is a very difficult world to make an impression.”

UCL Engineer, interview

“To what degree do community members or community organisations across London know about The Engineering Exchange and that the resource is there?”

UCL Engineer, interview

“What should be the strategy to reach out to all those that might need them?”

Community Participant, interview

“What I believe is that you have the right resources, but you need to pass them on to the right customers.”

Community Participant, interview

Interestingly, none of the participants mentioned the need for greater promotion amongst UCL staff or greater resource from the university to achieve its aims. This shows how in this case 'Mode 2' research was perceived by those who participated to be an initiative that mostly benefits society, while not focusing on how its benefits could be deepened amongst the engineering community. Therefore 'Mode 2' research has much further to advance if it is to start to alter the 'core' of research practice (2001) as this would surely require greater investment from the university to cope with public demand.

From my own perspective it seemed that The Engineering Exchange could improve its impact through greater support from UCL, perhaps in creating requirements for more of its staff to participate in community generated research. The lack of acknowledgement of participants of the need for institutional reform highlights the importance of evaluating these processes from a social science perspective to uncover power dynamics. Engaging with participants about the process revealed an assumption about how the project could be improved that was not supported by experiences of the initiative in action. The projects which I evaluated were stifled by a lack of resources as opposed to a lack of community knowledge. Therefore, while the 'Mode 2' thesis can provide the impetus for research that includes the benefits of public participation, as demonstrated by the case of The Engineering Exchange, evaluating and amending these practices is vital to ensure that they are best supported by the institutions that they seek to enhance.

6. Conclusions

Using The Engineering Exchange's work related to air quality as an empirical example; this dissertation has made a case for evaluating 'Mode 2' research in new ways to provide dynamic insights into what these methods mean for a changed role for expertise in society. My findings show that further evaluation of these methods is key to ensuring that experimental environmental research continues to address underlying issues of power that might not be exposed by narrower forms of evaluation. I now provide a

summary of my findings to demonstrate that this use of the ‘Mode 2’ thesis can deepen academic understandings of new research methods in an engineering context and more widely.

Considering whether or not The Engineering Exchange was able to successfully achieve its aims relating to air quality highlighted one of the challenges of ‘contextualising’ the research process. While the collaboration of engineers and community participants led to innovative ideas for tackling the issue of air quality, these did not always lead to successfully realised projects. In line with Barry & Weszkalny’s observation(2013), this showed that through the process of ‘contextualising’ research it becomes vulnerable to being used for overtly political interests. Furthermore, it was observed that in the case of The Exchange, the projects had been most successful where they most closely resembled the disciplinary structures of engineering (as described by Michelfelder 2013). This highlights the caution that must be taken when applying the ‘Mode 2’ thesis to research to ensure that a process of ‘contextualisation’ does not detract from using the strengths of those involved.

My second research question asked how the engineers and community members defined success in order to investigate the central notion that in ‘Mode 2’ society there is a changed role for expertise, and did indeed reflect that contention. Despite The Engineering Exchange conceptualising its work as the communication of expertise from the expert to the public, the accounts of participants showed this understanding had been in fact been shifted in favour of a search for ‘credibility’. Participants did not so much say that that they had learned from the ‘experts’, as indicate that their existing ideas had simply gained extra authority. The common definition of success amongst the two groups aligned to the ‘Mode 2’ notion that the achievement of accountability has become recognised as a socially constructed activity (Nowotny et al. 2001). The mutual reciprocity between the engineers and community members for one another's skills shows that one implication of ‘Mode 2’ evaluation is that emphasis on the soft-skills of

researchers is an unnecessary future focus for evaluation of interdisciplinary practice (as was the case in Bruce et al. 2004, Tomkins 2005, Mansilla 2006).

Despite the use of a narrative approach it was difficult to determine if the engagement with the project had any lasting impacts on participants. The research outputs produced did not reflect a change in the 'core' of the research process, which left the stories of participants the only means to determine any changes symptomatic of 'reverse communication' (Nowotny et al. 2001). While it was difficult to determine changing values through the interview process, The Engineering Exchange did represent a novel way of working for the engineers involved, who were used to collaborating with industry partners. Willingness to participate in such processes, however, could be seen as evidence that they have a potential for a more transformative impact if they were more widely used to shape research. Critics of science have argued for the need to change the mind-sets of its practitioners (e.g. Pielke 2007, Stilgoe 2009) which remains difficult to evidence through research. However, as this study shows, participants will need to be open to having their practice changed by the experience of collaboration, rather than seeing their role as simply sharing their existing expertise.

Finally, I considered how personal accounts of 'Mode 2' research can add further insights for the use of these methods through the case of The Engineering Exchange. While my evaluation confirmed both the strengths and weaknesses of the 'Mode 2' thesis, this approach was able to expose key areas of specific improvement for the initiative. Firstly, the Engineering Exchange would benefit from more clearly articulating its intentions to community participants. Where these had failed to be communicated effectively this lead to some confusion over what could be expected from the project. This suggests that the intention to secure public participation in engineering research cannot be generalised into the design of projects as they risk losing a clear focus to their work. Secondly, despite observing the ease with which different stakeholders worked together, this cannot be assumed to mean that power dynamics between groups are no longer significant. The recommendation that the project needed to reach

more of the community overlooked the need to gain input from a greater number of engineers from across the University. An increased emphasis on support within UCL could have the potential to start a process of ‘reverse communication‘. Therefore I believe that the institutional structures, within which ‘Mode 2’ research is conducted, remain a vital place to challenge power dynamics through its ability to generate and develop new ‘contexts’ for research.

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Annex 1. Original Research Proposal

An evaluation of Mode 2. knowledge-making in practice: The Engineering Exchange

Context

- Primacy of technological fixes and a re-engineering of the built environment
- Need to mobilise citizens in order to solve real-world problems
- Growth of interdisciplinary research practices as a way to produce 'better solutions' for society (Nowotny 2017)

GOAL	To explore the contribution that innovative research processes can make to the democratisation of knowledge production			
PURPOSE	An evaluation of Mode 2. knowledge-making in practice: The Engineering Exchange			
OBJECTIVES	Explore how participants engage with the research process	Conduct analysis of research outputs produced	Evaluation of project impact	Theorise a framework for evaluating Mode 2 research
RESEARCH QUESTIONS	**How did participants engage with the Eng Ex?**	**What types of knowledge were produced as a result of the EngEx?**	**Can we identify project outcomes from these outputs?**	**How can we measure the impact of Mode 2?**
ACTIVITIES /OUTPUTS	Research methodology 15-20 semi-structured interviews Interview transcripts Key themes identified	Collate research outputs Categorise types of knowledge Key themes identified	Comparison of key themes emerging from participant interviews and research outputs Comparison of project outputs against project aims Identify outcomes of research process	Analysis of project outcomes and key themes in the literature Identify key indicators
OUTCOMES	Understanding of participant engagement with the Engineering Exchange	Key themes identified from research outputs	Theorise project outcomes	Evaluation framework

Key Literature

Resituate politics within techno-scientific solutions (Latour 1993)

New types of knowledge creation:

- ❖ 'Post-normal science'(Functowitz and Raveetz 1993)
- ❖ Democratisation of Science (Pielke 2007, Castree 2014)
- ❖ 'Citizen Science' (Silverton 2009, Irwin 1995, Haklay 2015)

Mode 2 in practice

Evaluation focuses on the processes as opposed to the outcomes of research

New challenges: peer review and quality control (Mansilla 2006, Klenk and Meehan 2015, Bruce 2004, Popa et al. 2015).

Inequity of community engagement (Reed 2008)

Research needed to explore if these practices enhance democracy.

Case study: The Engineering Exchange

- A group of engineers and community members based at UCL
- Provide a match-making service: matching community groups with engineers, working together to find solutions
- Launched in 2014: 'Demolition or Refurbishment of Social Housing? A review of the evidence'
- Community engagement as a two-way process

Engineering Exchange: Air Quality

- Community-led data gathering
- Multi-stakeholder forum
- Reports

An evaluation of Mode 2. knowledge-making in practice: The Engineering Exchange

- How did participants engage with the practice of the EngEx?
- What types of knowledge were produced by the EngEx?
- Can we identify project outcomes from project outputs?
- How can we measure the impact of the EngEx?

Research Methods

- 15-20 semi-structured interviews: engineering researchers and community members
- Discourse analysis of project outputs
- Grounded theory data-analysis
- Theorise an evaluation framework

Value of Research

- Address gap in literature between Mode 2 theory and practice
- Potential value to Engineering Exchange in identifying an evaluation framework
- Contribute to debates on the democratisation of knowledge production

An evaluation of Mode 2 knowledge-making in practice: The Engineering Exchange

Background/context

The quest for sustainable development has thus far focused on a reengineering of the built environment. However, these solutions cannot be designed by engineers alone. Technicians are increasingly aware of the need to engage communities in their work but this process is far from easy. UCL's Engineering Exchange aims to provide community-engaged engineering research that is cultivated through partnerships with community groups.

"The EngEx believes that community engagement is a two-way process, with communities benefiting from access to leading-edge research outcomes and researchers and students benefiting from community knowledge and problem identification."

Literature

Scholars have questioned the ability of experts to find solutions to the 'manifold, messy and complex' (Nowotny 2017) problems of today. Theorists have argued for models of scientific practice that incorporate stakeholder models inspired by the values of deliberative democracy (Castree 2014, Pielke 2007, Collins and Evans 2007, Functowitz and Raveetz 1993, Gibbons et al. 1991, 2001). Mode 2 is a new paradigm of knowledge production which is socially distributed, application-oriented, trans-disciplinary and subject to multiple accountabilities (Gibbons et al. 2001). However Mode 2 is a call to action, as opposed to empirical studies, so we are left wondering what these new institutions of science imbued with reflexivity might look like. A more recent essay by Nowotny notes the need to 'systematically explore the implications of these ideas for systems and institutions in general' (Nowotny et al.2003:192). Evaluation of interdisciplinary research remains limited and all stated the challenge of peer review and quality control to be an unresolved challenge (Mansilla 2006, Klenk and Meehan 2015, Bruce 2004, Popa et al. 2015).

Aim/research questions

To explore the 'widespread imaginary of interdisciplinarity' (Nowotny 2017): does it produce better science and better solutions for society?

How can we evaluate Mode 2 knowledge?

What are 'novel forms of quality control'?

Does integration lead to less conflict?

Do knowledge hierarchies persist?

Methodology

This will incorporate the five aspects of Mode 2 Science (Nowotny et al.)

- Knowledge is generated within the context of application
- Trans-discplinarity
- Knowledge produced at a diversity of sites
- Reflexivity
- Novel forms of quality control

The following methods will be used:

- Semi-structured interviews: engineers who participated in the project.
- A discourse analysis of research outputs and toolkits.

Timeline

May –June: Literature Review and Methodology

June-July: Collect data

July-August: Writing and analysis

Research Value

A study of Mode 2 in practice

Design of an evaluation framework for the Engineering Exchange

Annex 2. Research diary

Date of entry	Discussion/task	Actions/Comments
08/03/17	Meeting with Sarah Bell to discuss The Engineering Exchange	Further meeting arranged to discuss possibility of evaluation
16/03/17	First supervision meeting with Russell - discussed the idea of evaluating The Engineering Exchange and ‘Mode 2’	Revised research proposal
20/03/17	Second meeting with Sarah Bell to discuss evaluation proposal	Provided access to Dropbox where I could access project documents
28/03/17	Second supervision: discussed whether to focus on both engineers and community members or one group	Find out from Engineering Exchange about access to participants
02/03/2017	Meeting with Sarah Bell: discussed access to participants, no problems foreseen	Set date for introduction to participants

09/05/2017	Supervision with Russell to run through presentation	Amendments made to define research aims more clearly
11/05/2017	Oral presentation	Nerve-wracking process but I feel I did a good job.
16/05/17	Supervision: feedback on oral presentation Suggestions for the key areas to cover in literature review and shared suggested interview schedule	Pleased with the positive response to my project idea More reading needed in critical accounts of Mode 2
12/06/17	Linking email sent by Charlotte (Engineering Exchange Project Manager) to participants	Follow up emails myself
13/06/17 -07/07/17	Conducted interviews with participants of Engineering Exchange	Enjoyed meeting a range of different people with different interests and experiences. However the process was more time consuming than I initially thought it would be.

		Found myself going off-topic in a number of interviews due to my own interests in subject matter discussed.
13/06/17	Meeting with Gemma at the UCL Public Engagement Unit who advised me about conducting evaluations	Concerned that I may have become too focused on the evaluation process over producing a good disertation.
20/06/17-15/07/17	Reading and drafting of literature review in time for draft submission	Found it challenging to read alongside conducting interviews Managed to submit 3000 words - but no analysis yet
15/07/17-01/08/17	Transcribing interviews	Very time consuming, however a good way to get to know the data collected

18/07/17	Feedback received on draft material	A lot of work needed to rework literature review and refine ideas.
21-21/07/17	Interviews conducted with Sarah and Charlotte	Good opportunity to reflect on my ideas so far following participant interviews.
26/07/17	Thoughts on research process: engineers harder to arrange interviews with/less eager to participate. Community participants talk at great length, seem to appreciate a listening ear to their ideas!	
01/08/17- 10/08/17	Survey of project documentation	Starting to generate ideas for themes, preferred using paper copies over an electronic programme.
11/08/17 - 18/08/17	Analysis and starting to draft chapters	Worried that not enough clear themes emerged from research/concerned that I am

		reinforcing the failings of the 'Mode 2' argument
18/87/17-28/08/17	Reworked literature review and continued to write analysis	Starting to feel nervous as deadline approaches - still a lot left to do!
31/08/17	Finally drafted introduction and conclusion	
03/07/17	Finished just in time for deadline	

Annex 3. Interview consent form

UCL DEPARTMENT OF GEOGRAPHY

DISSERTATION INTERVIEW CONSENT FORM

Project title:	An Evaluation of the Engineering Exchange
Location(s):	London
Project Supervisor:	Dr. Russell Hitchings
Brief description of the work:	This study will involve interviewing the participants involved in the Engineering Exchange.

Research Purpose

Thank you for agreeing to discuss your involvement with the Engineering Exchange. I am a master's student in Environment, Politics and Society at UCL who is conducting an evaluation of the work of the Engineering Exchange for my dissertation research. This evaluation aims to explore stakeholders' experiences and identify key lessons from the project which could be shared more widely. The broader objective of my dissertation is to investigate participatory research processes and the contribution they might make to knowledge-production that is more democratic.

Research Process

I will be conducting interviews with individuals who have been involved with the Engineering Exchange to learn more about their experience. I am particularly interested in the processes of the project such as how you became involved, what your experience was like, and any resultant successes or challenges. I will be recording and transcribing these interviews in order to analyse this data and code for any emerging themes. The interviews data will be complemented by an analysis of written project documentation.

Confidentiality

Everything you say will be treated as confidential. This consent form is designed to ensure that you understand the terms of your participation:

- The interview will be recorded and a transcript will be produced

- The transcript of the interview will be analysed by Hannah Cane as a researcher
- Access to the interview transcript will be limited to Hannah Cane and academic colleagues
- Any summary interview content, or direct quotations from the interview, that are made available through academic publication will be anonymised so that you cannot be identified
- Care will be taken to ensure that other information in the interview that could identify yourself is not revealed

Consent

By signing this form I agree that;

- I am voluntarily taking part in this project. I understand that I don't have to take part, and I can stop the interview at any time;
- The transcribed interview or extracts from it may be used as described above;
- I don't expect to receive any benefit or payment for my participation;
- I can request a copy of the transcript of my interview and may make edits I feel necessary to ensure the effectiveness of any agreement made about confidentiality;
- I have been able to ask any questions I might have, and I understand that I am free to contact the researcher with any questions I may have in the future.

Participant Signature

……..

Date

Researcher Signature

……..

Date

……

.....

Annex 4. Interview Excerpt: Giles

H: Could you outline your involvement with the Engineering Exchange?

G: Just a single project, which was all about trying to increase the amount of freight being moved around the canals in London. So the background is there is a community group, Del Brenner, from Regents…

H: Regents Canal network?

G: Something like that yep, anyway. Del is a very passionate guy who has spent a lot of time on the water and he saw an opportunity to get traffic off the roads in London and onto the canal. So we got involved as naval architects, to come up with technical solutions to the problem. So what kind of vessels might you be able to design, using more modern technologies than when the canals were built.

H: So Del got involved with the Engineering Exchange and they got in touch with you. So how did it unfold?

G: So the way that we did it, we has a masters student who was a naval architect who looked at the logistics, operational aspects. From that came up with requirements, then came up with a design for a barge and tug system that could work on the canal. The idea was to give that to Del who could then use that to get funding to take the project forwards. If you want people to get behind this as a notion you have to show them how it actually works, so because at the moment there's no freight at all. If you were going

to put freight on how would it actually work, so we came up with a technical solution to that.

H: So what were the outputs?

G: So there was a report. The logistics, how far you might try and go and in what time frame. How that might lead on to the design requirements. Then come up with drawings and technical specifications. This is the kind of vessel that could actually do it.

H: Costing?

G: That's kind of hard, some costing, that's kind of hard without going to a much higher level of detail.

H: What happened next?

G: The following year, I asked one of the group design teams (engineering MSc) to do a more detailed design for a zero emissions vessel to do this freight, with the idea that if you were actually going to go ahead with it you would want something with a minimal carbon footprint. These were mechanical engineers, by the end of the year they had a more detailed design that was hydrogen powered. They also built a model which was tested in water tanks in the basement here and they tested it and it was radio controlled. Again the idea was, they were shooting videos, providing this model solution again it was more information for Del to go out and talk to other stakeholders who might be able to support this in a bigger way.

H: This directly influenced your teaching? Is that a new influence?

G: The difference is, I've done a lot of work in the past with industry, one of things with Engineers is universities often have strong links with different companies. For example a ship design company, I'd ask them to give me a realistic specification for students to work to. The difference here is that this was much more about the community, so working with people outside the university I'm relatively used to, but working with the community was a new thing.

H: How did this differ?

G: Well it's tricky because I only have one statistic, but the thing is people like Del, I would imagine it would be similar at other times because he's so passionate. His enthusiasm gets people revved up. Students gained from having Del to bounce ideas off. Henrik, the original masters student, said well what about an autonomous vessel, so one that does not need a crew. So you can run it using sensors, keeping labour costs down, Del said he hadn't thought about that before.

H: So Del came in to engage with students?

G: Yes

H: So has Del had any success in gaining funding?

G: We tried to work with him to get some additional funding, to me the next step would be to get some serious funding to get a PhD project out of it. And it's a bit frustrating because the people you think would be most interested, TFL, they are just impossible to

work with. They don't have anybody in charge of water aspects. They have someone, but they don't have a phone number, they don't reply to emails. D'you know what I mean? Its just impossible. I've tried with other parts of the uni who do have good links with TFL, but its just been impossible.

H: how about the mayor?

G: Yeah I mean some of the councillors are interested in water-based alternatives.

H: So do TFL have any resource for water based alternatives?

G: Not that I'm aware of, its pretty dead. Which is surprising as they have the clippers. That's my assessment anyway.

H: So you have this model, but it has been stalled by lack of funding?

G: Lack of funding to go to the next level. The natural step now, theres a limit to what a masters student can do, you need someone with a decent amount of time to get to the deeper level.

H: You remain in touch with Del?

G: Yes

H: Do you know if Del has approached other funders?

G: I know he talks to people all the time. The thing is Del's enthusiasm, I don't know how that would be received by people in power, they don't respond well..

H: I understand. Do you think the department might do more of this type of work?

G: I'd love to do more. I've been to a few events, its just no one from the community has come forward with an idea that matches my interest/expertise. But if they did I'd be really interested to do something again. Because again, so I work with industry, it's nice to have that different perspective. Because I think the whole ethos of the EE in terms of providing engineering expertise to groups who would ordinarily struggle to get that sort of input is a brilliant one.

H: How would you describe the Engineering Exchange?

G: Trying to mobilise that connection between engineering experts and mainly university based people at the moment, they have aspirations to get industry people involved too, to provide expertise community groups who need that, but would not ordinarily know where to get it. So yeah some of those events there been some fascinating issues that have some up. There were some people looking at the timing of pedestrian crossings, sometimes it takes a long time for the lights to change. So neuro psychology that tells us that the cars are in touch, so the idea is it stops people walking so much and cross the roads dangerously. So the idea is how do you flip that around and make the pedestrian more important in that process. So they were looking to get some technical input to model it and see what the implications would be. That to me was another example of a community group with a great idea, that needed some technical input to take it to the next level, some evidence to their lobbying.

H: What is the role for community in solving environmental problems?

G: Community groups are really good at defining some of these problems. Probably too often, Industry takes a commercial viewpoint, community is thinking from a totally different perspective. No industry is going to think of putting freight on the canal, no industry is going to think about changing pedestrian crossing, it takes people to come from a different angle.

H: Do you think EE is a good idea?

G: Oh yes yeah.

H: Do you learn anything personally?

G: I hadn't thought about doing anything like this before, I've had many projects over the years that were interesting, but nothing from a community.

Annex 5. Interview Schedule

Interview schedule: An evaluation of the Engineering Exchange

I am a master's student of Environment, Politics and Society and I am conducting an evaluation of the Engineering Exchange for my dissertation. This evaluation aims to explore stakeholders experiences' and identify key lessons from the project which could be shared more widely. The broader objective of my dissertation is to investigate participatory research processes and the contribution they might make to knowledge-production that is more democratic. There are no right or wrong answers to the questions I'm going to ask: I'm interested in both positive and negative comments. I'd really like your honest reflections. If at any time, you don't want to continue to answer questions, just let me know and we'll stop there.

Introductions

When did you first hear of the Engineering Exchange?

Which project were your involved in?

How did you come to be involved?

Can you tell me about the project?

Can you describe your individual contribution to the project?

What assets were you able to contribute?

What were the strengths of the process?

What would you change about the process?

How would you describe the impact of the project?

Did it match your expectations?

What were the successes?

Were there elements you would change?

How did you contribute to the project?

What did assets did you bring?

Who did you work with during the project?

Have you worked with engineers/community groups before?

What were the benefits of including community members/engineers? What assets did the groups bring?

Were you exposed to any other networks?

Did the process match your expectations?

What were the successes of collaboration?

What would you change about the process?

Did you stay in touch with anyone you met on the project?

Can you describe any subsequent happenings that you think the project influenced?

Has any more work happened following the project?

What would you like to see happen?

Have you planned any additional activities?

Were there any political/social achievements?

Would you work with engineers/community members again?

How would you describe the work of the Engineering Exchange?

Have you come across anything like this before?

What do you think the strengths of the idea are?

Would you have any suggestions for improving its work?

Do you think it's a good idea?

What did you learn from the experience?

What progress has been made? What has been completed?

Have you developed any new skills or recognised any strength?

What are your interests?

Do you have any further comments/insights that you would like to share?

Did I miss anything?

If that’s accurate, what other points are there to consider?

Anything you want to add or correct?

Is there anybody else you would recommend that I talk to?

Annex 6. Excerpt of Engineering Exchange Client Protocol

LONDON'S GLOBAL UNIVERSITY

UCL

EngEx Partnership Protocol – Community group

The Engineering Exchange provides technical and scientific knowledge and skills to community groups in London. Projects are designed and agreed in partnership between community groups and UCL engineering practitioners, with support from the EngEx team.

Who we work with:

We work with a range of local community based groups such as residents' associations, environmental groups and youth organisations. We aim to work with organisations who might otherwise find it difficult to access engineering expertise.

What types of projects we take on:

Community groups are welcome to suggest for consideration any problems or ideas they have to improve their community, local area or London more widely.

We work on projects that have a technical or scientific problem at their core. Engineering deals with technologies, the environment, buildings, transport, water, construction, healthcare technologies, security and designing against crime, energy, information and communication technologies and many more issues that might be important to community groups.

Project length can be an afternoon, six months or more.

The impact of the project doesn't have to be huge, but it does need to serve the community and benefit a group of people by improving knowledge of technical issues and contributing to better quality of life.

What we provide:

The EngEx provides knowledge and expertise about technical and engineering problems faced by communities in London. We will help you scope and focus your project, and match you with an engineering practitioner or practitioners who have knowledge and skills in your project area. We will also oversee progress reviews, and provide outputs including a report, fact sheets, briefings, videos, events, media coverage etc., as agreed in the project planning phase.

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