Unwrapping DIY enquiry:
The study of 'enquiry' in DIY practice
at individual, community & place levels

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by
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May, 2017

I, Cindy Regalado confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

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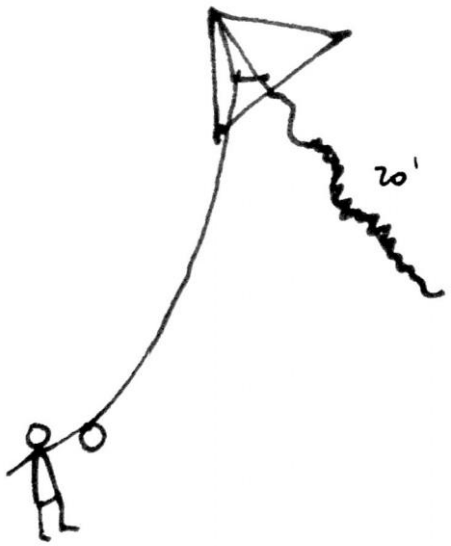
Cindy Regalado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Abstract

Do-It-Yourself (DIY) enquiry represents ownership over learning and action: figuring things out by oneself, experimenting, and questioning the state of things to find potential solutions to local concerns. It is an identifiable collective behaviour of self-reliance exhibited throughout our history but in the digital age and in societies with increasing levels of education, the way DIY practice unfolds is little understood. Traditional studies on public engagement in science and technology and perspectives on production of knowledge and technology have focused primarily on institutionally mediated methods of public participation and the validity of public contributions to established fields. This thesis research makes empirical, theoretical, and methodological contributions: using a multi-method approach and grounded theory for qualitative data analysis to explore DIY enquiry in practice, community, and place. The three in-depth case studies explore the nature of the production of knowledge, the role of technologies, and the barriers and opportunities to public engagement in DIY enquiry. Participant observation of a community of DIY practice reveals its inner processes, interactions, and framings of science and technology and how DIY practice is performed through DIY tool use and development. The design and facilitation of a DIY workshop series demonstrates the initial stages of engagement in DIY enquiry and reveals that barriers and opportunities to engagement are mediated by frame of mind, setting, facilitation, and interactions. The observation of place-based citizen initiatives of DIY enquiry reveals its range of interconnected actions: development of techniques and strategies for tool development, data interpretation, and leveraging of knowledge and stance for advocacy. Together the cases reveal the transformative power of DIY enquiry, how it builds knowledge, culture, and identity and that engagement requires curiosity, courage, commitment, and foundational competencies. They also reveal an inherent tension between DIY enquiry framed as a means (seeking collective/organised actionable goals) and as an end (enabling personal empowerment). This research facilitates a better understanding of the democratic potential of public engagement in science in our time but it also promotes the leveraging of knowledge production between professional/institutional science and civil society.

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Table of Contents

Acknowledgements 5
List of Figures 12
List of Tables 14
List of Boxes 16
List of abbreviations 16
1. Introduction 17
1.1 Contextualising DIY 17
1.2 The problem and significance of DIY enquiry 19
1.3 Foundations and motivation 21
1.4 Gaps in understanding 25
1.5 Contributions of this research 27
1.6 Thesis roadmap 30
2. Situating knowledge and enquiry 34
2.1 Defining knowledge 34
2.2 Production of knowledge and factors affecting its production 35
2.2.1 Prior and tacit knowledge 35
2.2.2 Reflexivity 37
2.2.3 Spaces for experiential learning 39
2.3 Shaping of knowledge and enquiry 40
2.4 Uses of knowledge 42
2.5 Manifestation and sharing of knowledge 45
2.5.1 Tensions in 'expert knowledge' 45
2.5.2 Insights into the initial stages of knowledge production through DIY 47
2.6 Practice-based perspectives on knowledge 48
2.7 Situating knowledge in DIY enquiry 52
3. Situating technologies 54
3.1 Defining technology 54
3.2 Perspectives on technology as tools for analysis 57
3.3 Conceptualising DIY technologies 61
3.3.1 Notions on citizen-led initiatives 62
3.3.2 Enquiry and DIY technologies 63
3.3.3 Tensions from the institutionalisation of expertise 65
3.3.4 Power in technical DIY 67
3.4 Factors affecting development and use of technologies 68
3.5 Challenges and opportunities DIY practices and technologies 70
3.6 Situating DIY technologies 72
4. Situating public engagement 75

4.1 Defining engagement and participation 75
4.2 Conceptual perspectives on engagement 76
4.2.1 Linking knowledge to action 77
4.2.2 Conceptions of engagement in citizen science 81
4.2.3 Hacking and grassroots engagement 84
4.3 Challenges in public engagement 88
4.3.1 Limits to engagement 88
4.3.2 Opportunities for engagement 91
4.4 Public engagement in DIY enquiry 94
5. Theoretical framework: DIY enquiry and practice 97
5.1 Situating practices of DIY enquiry 97
5.2 Technology and the Colonisation of the lifeworld 100
5.3 Factors influencing practices of DIY: A theoretical framework conceptualising issues of inclusion and exclusion 105
5.3.1 Symptoms of the State 106
5.3.2 The status of science 110
5.3.3 Issues of (self-)trust 114
5.3.4 Cognitive/technical mastery 116
6. Methodological theory 120
6.1 Methodological overview 120
6.2 Methodological orientation: ontological and epistemological assumptions overview 121
6.3 Guiding ontological and epistemological assumptions in Social studies of Technology 122
6.4 Guiding ontological and epistemological assumptions in Symbolic Interactionism 124
6.5 Contemporary approaches to Symbolic Interactionism 127
6.5.1 Extending Symbolic Interactionist epistemology 127
6.5.2 Complementing Symbolic Interactionism with practice-based perspectives 129
6.5.3 Generating and testing theory: method for data analysis in Symbolic Interactionism 132
6.6 The significance of a constructivist-interactionist theoretical tradition 132
6.7.1 Generating theory 135
6.8 Methodological design strategy: Multiple case studies 136
6.8.1 Rationale: Why use a case study approach? 136
6.8.2 Identifying the object and the subject of a case study 138
6.8.3 Case study selection: the purpose, approach, and process of a case study 139
6.8.4 Forging theory from cases 141
7. Methodological practice 144
7.1 Methodological design strategy in practice: Site selection 144
7.2 The case studies 145

7.2.1 Pilot case: Mildmay community centre 145
7.2.2 Pilot case: Citizen Science summit 148
7.2.3 Main case studies: an overview 151
7.3 This is how it all fits together: Research questions & methodological diagram 153
7.4 Data collection & fieldwork strategy: procedures and tools for data collection 155
7.4.1 Fieldwork strategy: roles of the researcher 155
7.4.2 Instrumentation and sources of data 159
7.4.3 Guiding concepts from observation 161
7.5 Data analysis strategy: Procedure in Grounded Theory 162
7.5.1 Using Atlas TI software for data analysis 168
7.6 Research quality 168
7.7 Limitations of the study 171
7.7.1 Researcher bias 171
7.7.2 Limitations on data collection 171
7.8 Ethics 173
8. A community of DIY practice: Case study background 175
8.1 Beginnings 175
8.2 The community and approach 177
8.2.1 Public Lab organisers 178
8.3 Public Lab community infrastructure, tools, and techniques 179
8.4 The Public Lab Barnraising 183
8.5 Methodological strategy: A community of DIY practice 184
9. A community of DIY practice: Case analysis 188
9.1 Comparative process and research dimensions 188
9.1.1 Initial guiding concepts and preliminary conceptual model 188
9.1.2 Dimensions and subdimensions 192
9.1.3 Theoretical sampling 194
9.2 Theoretical sampling: Community 195
9.2.1 Community culture, practices, and values held 196
9.2.2 Defining the community 199
9.3 Theoretical sampling: DIY tools 201
9.3.1 Use of DIY tools 201
9.3.2 Development of DIY tools 205
9.3.3 The 'actions' of DIY practice 207
9.4 Theoretical sampling: Knowledge 209
9.4.1 Reflective thinking and interplay between tools and issues 209
9.4.2 Production of knowledge 213
9.5 The nature of tensions in a community of DIY practice 215
9.5.1 Perceptions of inclusion 215

9.5.2 DIY as a means, DIY as an end 216
9.6 Integration and core concepts 218
9.7 Case conclusion 222
9.7.1 A community of DIY practice: review of propositions on framings, interactions, tools and meanings 222
10. Public engagement in DIY enquiry through playshops: Case study background 225
10.1 Background 225
10.2 The Explorer of the World playshop series: design and implementation 226
10.2.1 Playshop planning 226
10.2.2 Playshop facilitation 227
10.2.3 Playshop performance and delivery 227
10.2.4 Playshop contents and materials 228
10.2.5 Playshop series structure 228
10.2.6 Playshop engagement 231
10.3 Methodological strategy: DIY enquiry through playshops 231
11. Public engagement in DIY enquiry through playshops: Case study analysis 234
11.1 Comparative process and research dimensions 234
11.1.1 Initial guiding concepts and preliminary conceptual model 234
11.1.2 Dimensions and subdimensions 238
11.1.3 Theoretical sampling 241
11.2 Theoretical sampling: consequences of engagement 241
11.2.1 Workshop environment 243
11.2.2 Reflective thinking & enquiry 244
11.2.3 Different ways 246
11.2.4 Comfort zone extended 247
11.2.5 Interplay between consequences & conditions 248
11.3 Theoretical sampling: Barriers to engagement 249
11.3.1 Staying within comfort zone 249
11.3.2 Condition for engagement 253
11.4 Theoretical sampling: Initial steps to engagement 255
11.4.1 Making 255
11.4.2 Artistic expression 258
11.4.3 Reasons for engagement 260
11.5 The nature of knowledge & transformation in playshops 261
11.6 Integration and core concepts 263
11.7 Case conclusion 265
11.7.1 Public engagement in DIY enquiry through playshops: review of propositions on engagement, trust, and community 265
12. Place-based citizen initiatives of DIY enquiry: Background 270

12.1 Environmental issues and organisations in the Gowanus Canal 270
12.1.1 EPA and the Superfund 271
12.1.2 Gowanus Canal Conservancy 273
12.1.3 Proteus Gowanus 274
12.2 Citizen participation in environmental monitoring 275
12.3 Methodological strategy: Place-based citizen initiatives of DIY enquiry 282
13. Place-based citizen initiatives of DIY enquiry: Case analysis 286
13.1 Comparative process and research dimensions 286
13.1.1 Guiding concepts, dimensions, and subdimensions 286
13.1.2 Theoretical sampling 288
13.2 Theoretical sampling: Environmental issues 288
13.2.1 Contexts: Gowanus, government, & community organisations 289
13.2.2 Role: role of community organisations/citizen efforts 291
13.2.3 Artefacts: Infrastructure, pollution, & data 294
13.2.4 Actions: Identifying needs 296
13.2.5 Engagement 297
13.3 Theoretical sampling: Knowledge production, enquiry, and the DIY method 299
13.3.1 DIY: Citizen data and science efforts 300
13.3.2 Enquiry and the DIY method 306
13.3.3 Action: Providing proof 308
13.4 What is it all for? The nature of lobbying and advocacy 310
13.5 Integration and core concepts 312
13.6 Case conclusion 317
14. Discussion 320
14.1 Introduction: discussion of approach and method of analysis 320
14.1.1 Convergence of themes in case studies: Insights from Grounded Theory 322
14.2 Research questions answered 324
14.2.1 What is the nature of knowledge production in DIY enquiry? 324
14.2.2 What is the role of technologies in DIY enquiry? 327
14.2.3 What are the barriers and opportunities to public engagement in DIY enquiry, tool & technique development, and use? 331
14.2.4 Can and how can barriers be overcome and/or opportunities exploited? 336
14.3 Theoretical model revised 337
14.3.1 Symptoms of the state 340
14.3.2 Status of science 342
14.3.3 Self-trust 344
14.3.4 Cognitive and technical mastery 345
14.3.5 Revised concepts on engagement in DIY enquiry 347
15. Conclusion 350

15.1 Research approach, methods & cases: summary & reflections 350
15.2 Summary of research question findings 355
15.3 Theoretical contributions 358
15.4 Implications of the study and future research 361
16. References 364
Appendix A: Interview guides 382
A.1 Community of DIY practice 382
A.2 Public engagement in DIY enquiry through playshops 382
A.3 Place-based citizen-led initiatives of DIY enquiry 383
A.4 ATLAS.ti code manager example 383
A.5 Example of ATLAS.ti network view used for theoretical integration 384
Appendix B 386
B.1 Code list for Community of DIY practice case study 386
B.2 Full image of roles/perspectives on the DIY culture/movement 389
Appendix C 390
C.1 Code list for Public engagement in DIY enquiry through playshops case study 390
Appendix D 391
D.1 Code list for Place-based citizen initiatives of DIY practice case study 391
Appendix E 393
E.1 Perspectives from Action Research 393

List of Figures

Figure 1.1: Topics central to the study of DIY enquiry..... 25

Figure 1.2: Theoretical model on factors contributing to the possibility of public engagement in practices of DIY enquiry.....28

Figure 2.1: Modelling the literature on practice-based perspectives on knowledge and knowing..... 50

Figure 3.1: Modelling the literature on social shaping of technologies.....73

Figure 4.1 Approaches to Public Engagement in science and technology in quadrant model..... 78

Figure 4.2 Levels of hacking..... 85

Figure 4.3: Modelling the literature on Public Engagement to inform the study of engagement in DIY enquiry..... 95

Figure 5.1: Theoretical model on factors contributing to the possibility of public engagement in practices of DIY enquiry.....107

Figure 6.1. Typology of the case study: the process research design.....137

Figure 7.1: Balloon mapping at the Touch|Play|Learn exhibition, Mildmay Community Centre, 2012.....146

Figure 7.2. Research design for Mildmay community centre pilot case.....147

Figure 7.3: Arduino workshop by Tom Igoe at Citizen Cyberscience Summit 2012..... 149

Figure 7.4: Research design for Citizen Science Summit pilot case.....150

Figure 7.5: Research methodology diagram..... 154

Figure 7.6. Data analysis operations in Grounded Theory.....164

Figure 7.7. Process of constant comparison in data analysis using Grounded Theory.....165

Figure 7.8: Assessment of research quality.....169

Figure 8.1 Fishermen and community organisers working together to map the wetlands skirting the coast of Louisiana..... 176

Figure 8.2: Aerial photographs comprising a map of the BP oil spill in 2010..... 176

Figure 8.3: Public Lab tools at https://publiclab.org/tools..... 180

Figure 8.4: Public Lab mailing lists at https://publiclab.org/lists..... 182

Figure 8.5: Public Lab ethos as introduction on their website.....183

Figure 8.6: Research design for community of DIY practice case study.....185

Figure 9.1: Making an 'air quality egg'; workshop March 2012 in London.....189

Figure 9.2: Initial guiding concepts; aspects of the DIY moment: *the doers*, their actions, and concerns..... 190

Figure 9.3: Theme map for *community* – culture, practice, and definition of a community of DIY enquiry..... 197

Figure 9.4: Theme map for *DIY tools* in a community of DIY enquiry..... 203

Figure 9.5: Extract from a how-to guide on balloon-mapping..... 204

Figure 9.6: Tool development technique: how-to guide for making a camera rig from PET bottle....205
Figure 9.7: Multiple versions of PET bottle camera rigs – reflecting local resources and needs....207
Figure 9.8: Theme map for the coding category *Knowledge* in a community of DIY practice....211
Figure 9.9: Grounded theory for Public Lab as community of DIY practice....219
Figure 9.10: Closer look at 'culture and practice' and their relationships to tensions and conditions/enablers....220
Figure 9.11: Word cloud with frequencies for the 'ten things I value about Public Lab' written by 21 community members....221
Figure 10.1: Explorer's journal....229
Figure 10.2: Blog posts written by attendees to Explorer of the world playshops....229
Figure 10.3. Research design for public engagement in DIY enquiry through playshops case study. 233
Figure 11.1: Preliminary model and initial concepts of engagement in DIY enquiry....236
Figure 11.2 Theme map for *consequence of engagement*....243
Figure 11.3 Participants' comments on playshops' webpage....248
Figure 11.4: Theme map for *barriers to engagement* in DIY enquiry through playshops....251
Figure 11.5: Theme map for *initial steps in engagement* in DIY enquiry through playshops....256
Figure 11.6: Dimensions of DIY making and material representation....258
Figure 11.7: Frame from an animation film produced in a final playshop....260
Figure 11.8: Grounded Theory for the case study of public engagement in DIY through playshops....263
Figure 11.9: Inner part of Grounded Theory model for playshops: consequences of engagement....265
Figure 11.10: Revised conceptual model on engagement in DIY enquiry through playshops....267
Figure 12.1: Map of the Gowanus Canal with annotations of pollution sources and layer of historic hydrological features....271
Figure 12.2: Hall of Gowanus – view of exhibition section....274
Figure 12.3: 'Star of the Gowanus' Sediment – provided by the EPA to the Hall of Gowanus....275
Figure 12.4: Sections from a blog post presenting the issue and survey results from citizen-led enquiry into local pollution....277
Figure 12.5: Gowanus Canal community mapping of sewage plumes from hurricane Sandy damage, 2012....278
Figure 12.6: DIY aerial photographs showing 'milky sewage' plumes....279
Figure 12.7: A) DIY aerial photo with annotation of hypothesis and historic features. B) Digitised map from 1766 overlaid by a city ordinance map....281

Figure 12.8: Digitised historic map overlaid on DIY aerial photograph annotated with findings from CSI investigation..... 282

Figure 12.9: Research design for the place-based citizen initiatives of DIY enquiry case study..... 283

Figure 13.1: Theme map for *environmental issues*..... 290

Figure 13.2: Symbolic and material representation of the Canal's infrastructure, environmental issues, those perceived as responsible, and attitude toward the situation..... 295

Figure 13.3: Popular/fictitious representation of the Canal's environmental issues..... 296

Figure 13.4 Theme map for *Production of knowledge*..... 300

Figure 13.5: Sheen from coal tar in the waters of the Gowanus Canal shimmering in the sunshine.....302

Figure 13.6: Results from citizen data-collection on pathogen levels side-by-side with State data placed at the registration table of a canoeing event at the Canal……. 304

Figure 13.7 Grounded Theory for the case study of citizen initiatives of DIY enquiry in the Gowanus Canal: roles and framing from community organisations and the State..... 313

Figure 13.8 Engagement in DIY enquiry in a place-based context..... 316

Figure 14.1: Salient insights into DIY enquiry emergent in the three case studies..... 323

Figure 14.2: Revised theoretical framework on the factors influencing DIY enquiry. Synthesis of theoretical and conceptual models..... 338

Figure 14.3: Public Lab foldable spectrometer web-search showing Public Lab's page and the sales page on Amazon.....339

Figure 14.4: Revised conceptual model of engagement in DIY enquiry..... 348

Figure 15.1: Summary of the funnelling approach in this research Part 1..... 351

Figure 15.2: Summary of the funnelling approach in this research Part 2..... 352

Figure 15.3: Summary of the study of DIY enquiry at the individual level.....353

Figure 15.4: Summary of the study of DIY enquiry at the level of community.....354

Figure 15.5: Summary of the study of DIY enquiry embedded in place..... 355

List of Tables

Table 3.1: Considerations for the analysis of technological development applied to DIY..... 59

Table 4.1: Types of engagement in PPSR.....84

Table 4.2: Types of engagement in citizen science..... 84

Table 6.1: Overview of methodology.....121

Table 6.2: Significance of ontological and epistemological assumptions of symbolic interactionism for the study of the possibility of people engaging in DIY enquiry.....134

Table 6.3: Typology of case study purpose.....139

Table 6.4: Design frame for case study approach in the study of DIY enquiry.....141

Table 7.1: Criteria for case study site selection..... 145
Table 7.2: Sources of evidence for pilot case at the Mildmay Community Centre..... 148
Table 7.3: Sources of evidence for pilot case at the Citizen Science Summits..... 150
Table 7.4a: Main case studies overview..... 152
Table 7.4b: Case studies overview in timeline..... 152
Table 7.5: Summary of fieldwork strategy in direct observation..... 157
Table 7.6: Multi-method approach in role of researcher..... 158
Table 7.7: Interview approaches: informal and interview guide..... 160
Table 7.8: Themes for interview guides used in case studies..... 160
Table 7.9: Guiding concepts for the study of DIY enquiry..... 162
Table 7.10: Generative questions for data analysis: sources and types of questions for DIY enquiry..... 167
Table 7.11: Research quality criteria as applied to this research..... 169
Table 7.12: Overview of methodological practice..... 174
Table 8.1: Sources of evidence for community of DIY practice case study..... 185
Table 9.1: Themes & subdimensions generated through open coding of community of DIY practice case study..... 193
Table 9.2: Categories and their subdimensions (or subthemes) linked to the salient theme *Community culture and practices*..... 196
Table 9.3: Categories and their subdimensions (or subthemes) linked to the salient theme *DIY tools*..... 202
Table 9.4: Categories and their subdimensions (or subthemes) linked to the salient themes r*eflective thinking* and *production of knowledge*..... 210
Table 10.1: Explorer of the world playshop list..... 230
Table 10.2: Sources of evidence for public engagement workshops case study..... 233
Table 11.1: DIY Enquiry through playshops - categories and their subdimensions (or subthemes)..... 239
Table 11.2: Categories and their subdimensions (or subthemes) linked to the salient theme *consequence of engagement*..... 242
Table 11.3: Categories and their subdimensions (or subthemes) linked to the salient theme *Barrier to engagement*..... 250
Table 11.4: Categories and their subdimensions (or subthemes) linked to the salient theme *Initial steps to engagement*..... 256
Table 12.1: Sources of evidence for Place-based citizen-led initiatives if DIY enquiry..... 284
Table 13.1: Themes and their subdimensions – generated during open coding; DIY enquiry in the Gowanus Canal..... 287
Table 13.2: Categories and their subdimensions (or subthemes) linked to the salient theme *environmental issues*..... 289
Table 13.3: Categories and their subdimensions (or subthemes) linked to the interrelated salient themes *production of knowledge*, *enquiry*, and *DIY method*..... 299
Table 14.1: Symptoms of the state: challenges and implications for DIY practice..... 341
Table 14.2: Status of Science: challenges and implications for DIY practice..... 343

Table 14.3: Issues of Self-trust: challenges and implications for DIY practice..... 345
Table 14.4: Cognitive and technical mastery: challenges and implications for DIY practice..... 346
Table 15.1: Contributions to research..... 360

List of Boxes

Box 1: The public sphere as ideology..... 101
Box 2: A practical note for this and the next case study chapters..... 192
Box 3: EPA Superfund..... 272
Box 4: Organisational opportunities for & from practice..... 334

List of abbreviations

CA	Cognitive absorption
CAG	Community Advisory Group
CBM	Community-based monitoring
CBPR	Community-based participatory research
CCS	Citizen Science Summit
CSI	Creek scene investigation
CwB	Citizens without Borders
DEP	Department of Environmental Protection
DIT	Doing-It-Together
DIY	Do-It-Yourself
DIYer	Do-It-Yourselfer
EC	Epistemic curiosity
EPA	Environmental Protection Agency
EBtA	Exploring borders through art
EoW	Explorer of the World
GCC	Gowanus Canal Conservancy
GLAM	Gowanus Low Altitude Mapping
HCI	Human Computer Interaction
HoT	History of Technology
ICT	Information Communications Technology
IS	Information Systems
NIR	Near Infrared
OED	Oxford English Dictionary
MCC	Mildmay Community Centre
PAR	Participatory Action Research
PNS	Post-Normal Science
PoT	Philosophy of Technology
SCOT	Social Construction of Technology
SI	Symbolic Interactionism
SShT	Social shaping of Technology
SST	Social Studies of Technology
STS	Science and Society Studies
SuScit	Citizen Science for Sustainability project

1. Introduction

Do-It-Yourself (DIY) *enquiry* represents ownership over learning and action: having the capacity to figure things out by oneself, experiment, seek knowledge, and question the state of things to find potential solutions to local concerns or interests. It is an identifiable collective behaviour of self-reliance exhibited throughout our history but in the digital age and in societies with increasing levels of education, the way DIY practice unfolds is understudied and undertheorised. Traditional studies on public engagement in science and technology and perspectives on production of knowledge and technology have focused primarily on institutionally mediated methods of public participation and the validity of public contributions to established fields. This study aims at understanding practices of technologically-oriented DIY enquiry[1] (see Chapters 2 & 3 situating enquiry, production of knowledge, and technology). It makes empirical, theoretical, and methodological contributions: using a multi-method approach and Grounded Theory for qualitative data analysis to explore DIY enquiry in practice, community, and place. These three depths of DIY represent the personal level of the individual, a community of practice, and a physical locality. This introduction presents the context of DIY, gaps in understanding, the contributions of this research, and the thesis roadmap.

1.1 Contextualising DIY

There are two main trends leading to a step-change in engagement with science and technology today: the digital information age and increased educational attainment. Taking a step back into history, similar claims about social and technical trends were also being highlighted half a century ago. In the 1970s scholars such as Wilensky (1974) and Haug (1975) argued that rising levels of public schooling, the increased sophistication of the public, and computerisation were trends contributing to the erosion of the monopoly over knowledge. Haug (1975) argued that computerisation had changed accessibility patterns, which in turn were creating new divisions of labour and helped to disseminate practice skills and

[1] The OED defines 'enquiry' as the action of seeking for truth, knowledge, or information concerning something; an investigation, an examination. In the OED, 'research' refers to a systematic investigation or enquiry aimed at contributing to knowledge of a theory, topic, etc., by careful consideration, observation, or study of a subject. 'Research' is different from 'DIY enquiry' in that it most often refers to an original critical or scientific investigation carried out under the auspices of an academic or other institution.

information. The rhetoric of DIY in the 1960s and 1970s has a flavour of promoting 'accessibility' and the creation of tools that could be "built by any interested person in four hours for under $15" (Fasgenelli, 1965, p.1076), available and easy to use measurement tables for the DIY astrophysicists of the day (Haig, 1972), or change in our relationship to consumption by embracing frugality and purposeful DIY (Elgin & Mitchell, 1977). These trends also prompted sociologists to create a typology for amateurism (Stebbins, 1977; Haug, 1975). Arguing for a democratic and technical autonomy that "calls for an ever greater degree of self-direction, self-expression, and self-realisation", Mumford (1964, p.1) highlighted that

> the do-it-yourself movement prematurely got bogged down in an attempt to sell still more machines; but its slogan pointed in the right direction, provided we still have a self to do it with. [...] [T]he genuine advantages our scientifically based technics has brought can be preserved only if we cut the whole system back to a point at which it will permit human alternatives, human interventions, and human destinations for entirely different purposes from those of the system itself. At the present juncture, if democracy did not exist, we would have to invent it, in order to save and recultivate the spirit of man (Mumford, 1964, p. 8).

Mumford argued for the valuing of forms of work requiring special skills, knowledge, and aesthetic sense – not conceivable through mass production. Haug (1975) further argued that the social and technical developments of the time accompanied ideological challenges to the 'professional status' leading to a 'deprofessionalised' future. Specifically, she contended that "in the 21st century, now less than 25 years away, it seems very unlikely that 19th century patterns of obeisance, trust, and awe of superior knowledge will persist. But this is a hypothesis, not a prophecy. Like all hypotheses in social science, it can only be tested by history. We will have to check the findings 25 or 125 from now" (Haug, 1975, p.212). It is now 42 years later. What has changed?

What is different today is first, the way technologically-oriented DIY enquiry unfolds within the context of the digital information age in which technologies are changing. Second, DIY also represents a step-change in involvement in societies with a growing percentage of people with an education and understanding of scientific and technical processes – with access to open information on the Internet. Levels of education have increased over the last decade; for example, the rate of tertiary education attainment among adults (aged 25 to 64) in OECD countries increased by 13.4% between 2000 and 2015 (OECD, 2016). In the UK there was an increase from 29.7% in 1995 to 43.5% in 2015 in the attainment of tertiary education for

people aged 25 to 64 years to. In addition, the choice of subject area for tertiary education in the last decade in the UK has tended towards the sciences[2].

Haklay (2013a) has convincingly discussed the context and drivers of engagement in citizen science – the involvement of non-professional scientists in different levels of scientific research. Haklay argued that the blossoming of citizen science is due an interplay between technical and social trends. There is a step-change in involvement because of the ubiquity of digital technologies at more accessible prices. This is coupled with an increased availability of home broadband and access to storage and processing power in personal computers and digital devices. In essence, technological advancement has meant that many people are now carrying powerful mobile devices with effectual computational and environmental sensing abilities 'in their pockets'. Haklay (2013) also points out that while millions of people have attained science or engineering-related higher education, they do not necessarily use the acquired knowledge and skills in their daily life. Together, these social and technical trends point to a tremendous burgeoning of possibilities for participatory and collaborative activities such as citizen science; those with an interest in science but who cannot fulfil it in their occupations can explore it through various citizen science activities. This is not to say that only those with tertiary education are able to participate but rather points to trends that cannot be ignored. As noted by Haklay (2013), it also indicates an inherent bias in the socio-economic make up of citizen science – and therefore the study of it. Most importantly, it points to an underlying problem of inequality and exclusion in participatory approaches to science and technology, which I describe next.

1.2 The problem and significance of DIY enquiry

DIY enquiry is linked to a variety of socio-cultural issues. These range from feelings of isolation, disconnect, and estrangement from technologies to the more systematic mechanisms of exclusion that are introduced with advancements in technology. Many of these issues are not well understood and they widen the access and information gaps in our societies when not addressed. There are also claims as to the democratisation and

[2] For example, in the UK during the 2015/2016 enrolment period 42.3% of students engaged in postgraduate studies were registered in science subject areas (including 16.5% medicine and related; 7.3% engineering and technology; 6.7% biological sciences; 3.7% physical sciences). Furthermore, between 2011/2012 and 2015/2016 there was a 14.2% increase in people having obtained a doctorate degree and 44.3% increase in people having attained their first degree (HESA, 2017). A total of 23,345 people attained doctorate degrees and a total of 88,890 attained their first degree in 2015/2016 (ibid).

empowerment that participatory science and technology brings, yet there are no institutional mechanisms in place to recognise and formally engage with the contributions from those participating.

Our daily lives are mediated by ubiquitous digital devices. Some of these we are not even aware of, and most of them we cannot readily understand let alone try to repair by ourselves. Many, perhaps most of them, are not meant to be opened by 'ordinary folk'; they are designed as end products for 'consumers'. This trend in part has given rise to a feeling of estrangement from technologies but also, in response, it has given rise to the 'Maker' ethos 'if can't open it, you don't own it' (Jacoby, 2013; Jalopy, 2005). These ubiquitous devices also point to pressing sources of concern (e.g. measuring pollution, surveillance, etc.) but also opportunities to network grassroots responses.

In addition, as technology progresses, new mechanisms of exclusion are introduced, the sources and impacts of which are not acknowledged or little understood (Dunbar-Hester, 2014). These mechanisms for exclusion can be technical (e.g. designer's choices in app development as I explain in chapter 3), regulatory (e.g. exclusionary standards and regulations), socio-cultural (e.g. through perpetuation of unquestioned practices as I discuss in chapter 2), etc. These mechanisms of exclusion are problematic when the issues of access and power are left unaddressed because we run the risk of making the already information rich richer. It is not within the scope of this study to unravel the problematic of industrial production, but it helps us to situate the significance of DIY enquiry at the (dis)junction between people, technologies, and knowledge.

Advocates of citizen science and participatory approaches to science and technology support the idea that the digital information age promises a shift in the redefinition of who can do science, thereby democratising scientific practice; as Nielsen (2012) pointed in his influential and provocative book "Reinventing Discovery" "all that's lacking are the tools that help connect [laypeople] to scientific communities in ways that help them make [a] contribution to science. Today we can build those tools" (M. Nielsen, 2012, p. 155). Thus, an emancipatory era aided by increased access to tools and information, some claim, is changing the way we consume, share, create, and do (Foth, Forlano, Satchell, & Gibbs, 2011; M. Nielsen, 2012; Schickler, 1994). While the rhetoric of DIY in the 1960s and 1970s was one pointing to autonomy and decentralisation, just as today, it does not necessarily examine the various factors contributing to or hindering the possibility of DIY enquiry nor does it examine DIY as a socio-cultural phenomenon with various depths.

In addition, an enthusiastic support by popular media (e.g. Wired and MAKE magazine) and government (e.g. ICT4D) coupled with eager claims about the decentralisation and democratisation of knowledge production, science, and technology through 'bottom-up' participation is overshadowing the need for critical examination; this excitement leaves unanswered questions about who participates, in what, and what the nature of that participation in these activities is (Dunbar-Hester, 2014; Haklay, 2013b; G. Ottinger, 2009). Some scholars in Technology Studies warn that we should not confuse participation with democratisation since the latter is much more than mere access to technology (Marshall, 2003).

Therefore, while participatory approaches such as citizen science and DIY have the potential to 'pull the curtain back' on some areas of science and technology previously rendered exclusive, and even enable or encourage people to carry out their own investigations, as technology progresses the new mechanisms of exclusion that are introduced need thorough investigation (Elwood, 2008; Haklay, 2013b). One issue identified by Rydin (2007) is the lack of mechanisms at the institutional level that can enable the handling of multiple knowledges in a way that recognises the specificity of knowledge claims. The Socientize White Paper on Citizen Science for Europe (2014) also calls for new institutional arrangements to promote the validation of bottom-up knowledge claims. Understanding exclusionary mechanisms helps to identify and address the barriers to fulfilling the potential of the social and technological trends of today. It can also help to fulfil the 'empowerment' promise of citizen science in the whole of its spectrum.

In this research I aim to understand what practices of DIY enquiry do to people and what people do with these because the overarching questions is 'does this phenomenon make science more inclusive or less inclusive? And for whom?' By examining what the barriers to engagement in DIY are, including what barriers are created within it, this research adds to the debate on democratisation of science.

1.3 Foundations and motivation

My interest in the topic stems from my own journey into DIY; a journey into self-learning with DIY electronics and DIY tools for environmental monitoring which led me to wonder what the initial steps in this journey might be and if these could be identified and promoted.

The topic also extends from my interdisciplinary MSc degree in Rural Planning and Community Development at the University of Guelph and my Master's research on community adaptive strategies to rapid socio-economic change in which I investigated how people provided solutions to pressing needs in their community when the local authorities could not (Regalado, 2009). I am also highly motivated to pursue this topic because of the impact that initiatives such as the Public Laboratory for Open Technology and Science have had on redressing local social and environmental issues. Through their efforts they have inspired, shared, and worked with others around the world to do the same. This research was also motivated by my reflection on the various citizen science conferences I attended in 2012 and 2013 and the numerous interviews I conducted with attendees. One poignant aspect was the near absence of 'citizens' at these 'citizen science' events. Themes from the interviews pointed to the sharp contrasts in 'participatory' approaches to engagement in scientific research (e.g. crowdsourcing, citizen sensing, community-based, etc.) and the motivations/justifications for employing those approaches (e.g. behaviour change perspective, focus on science education and a need to increase scientific literacy, issues of power and democratisation of science, etc.). This led me to consider the ontological and epistemological assumptions on which my research would be based (Chapter 6). Review of the literature revealed a gap in research on citizen-led initiatives and this combined with the above reflections and themes led me to focus on the significance of context, setting, method, and initiative-taking. I was also inspired by the aim of Sir Ken Robinson's (2009) book "The Element" to "offer a richer vision of human ability and creativity and of the benefits to us all of connecting properly with our individual talents and passions" (2009, p.xiii), which is at the core of DIY enquiry. Together, these experiences, literature, and personal involvement in DIY led me to consider an alternative and parallel approach to understanding the possibility of DIY enquiry and in particular, the production of knowledge in the use and development of DIY tools and techniques. Based on this, I designed public engagement activities – workshops and playshops – as ways to introduce methodologies for DIY enquiry involving hands-on activities with technical tools and techniques. These in turn afforded an opportunity to study the initial stages of engagement in DIY enquiry and the concomitant barriers/opportunities to engagement in it (Chapter 5). With this experience and insights from initial data analysis (using Grounded Theory – Chapter 6), I narrowed my research to the salient topics of production of knowledge and the role of technologies in citizen-led enquiry and the processes surrounding these DIY practices. My original interest was on the process of knowledge production and people's participation in that process. However, my review of the literature on Sociology of Technology also revealed that the topic of

technologically-oriented DIY had been covered by only a handful of scholars (and in many cases indirectly). This presented a motivating opportunity to make a contribution to this field. My ultimate motivation was to give a full understanding of what people do with practices of DIY enquiry, what these practices do to them, and what factors contribute to this. Each of the cases in this research is as unique as the people within them – people whom I have had the pleasure to know and work alongside through this research. I hope this research not only makes valuable theoretical and methodological contributions to Technology Studies but also does justice to their remarkable stories and efforts, which I have attempted to convey with empathy, artistry, and academic endeavour in equal proportions.

Beyond aspiration, inspiration and motivation, practices of DIY enquiry are intrinsically worthy of attention because there is growing evidence supporting that these types of practices:

- are identifiable as a collective behaviour of self-reliance (Wehr, 2012);
- represent potential alternatives to academic/institutional or industrial-based approaches to research and problem-solving (Wehr, 2012; Wylie, Jalbert, Dosemagen, & Ratto, 2014);
- represent specific kinds of (and often overlooked) local knowledge, issues, and politics at the local scale (Dunbar-Hester, 2014; Miller-Rushing et al., 2012; Wylie et al., 2014);
- represent responses or critiques to systemic pressures and can provide the opportunity to pinpoint and revise existing norms and regulations (Feenberg, 2008; Morozov, 2013; Wehr, 2012);
- have the potential to provide means and spaces where people can develop and master their own skills and tools, build collective expertise, and leverage it to decide their own path of action (Fischer, 2011b; Kemmis & McTaggart, 2005; Kera, 2012; Paulos, 2013; Ratto & Boler, 2014b); and
- far from being isolated social phenomena, they are now having impact on policy (Bal et al., 2014; Gigler & Bailur, 2014; Smith et al., 2017; Wylie et al., 2014).

In this research I argue that DIY enquiry has various transformational depths – at the levels of place, community, and self. Additionally, the factors influencing DIY enquiry operate differently at these depths. I also argue that it is through ownership over experience in the process of enquiry, i.e. exploring and seeking knowledge, that agency and self-reliance are

kindled. I further argue that by understanding the barriers and opportunities to DIY enquiry we can purposefully create the interactions, spaces, and even mechanisms that spark meaningful engagement in enquiry.

However, to understand the highly personal and experiential context of DIY enquiry in both social and technical senses, we need to grasp the unique nuances of knowledge production in DIY and do it in its technological dimensions. Hence, I first assume that *knowledge* is deeply embedded in material practice and that there are multiple (but not always discernible) pathways and contributions to knowledge creation. Second, I assume that *technology* is an important aspect of DIY making and practice; through personalised designs, codes, filters, and algorithms technologies developed and used in DIY provide different ways of capturing, sharing, telling, and representing the way we make sense of the world (including misuse, misrepresentation, etc.). In addition, because I am not merely interested in individual practices we also need to look at its *engagement* dimension and understand DIY enquiry as a social phenomenon. Figure 1.1 portrays these three interrelated topics, which are central to the study of DIY enquiry. These aspects of DIY are explored in depth in three corresponding literature review chapters.

Understanding what people do with and through the practices of DIY enquiry as well as what these practices do to them is significant because it can help to fulfil the potential of technological and societal trends we experience today. The methodologies, framework, and model developed through this research can provide support to communities and researchers seeking to maximise the benefits of DIY enquiry, ensuring the risk of making the 'information-rich richer' is averted.

This thesis takes a socio-technical approach to qualitative research and employs thick description (p.124) to provide detailed information about the technical, social, and political aspects of the cases under study (Bijker & Pinch, 2011). Thick description creates a wealth of information but it does so in a way that captures as much of the nuances and richness of the topic of DIY enquiry. This thick description is subsequently simplified through theoretical integration using Grounded Theory, as I explain in the methodology (p.163), but takes a holistic rather than reductionist approach employing condensed models that point to limited aspects. Thus, the purpose of the refracted literature is to situate and guide the initial direction of the research (providing detailed conceptual models in each chapter), while the discussion and analysis aim at inductively identifying and theorising the many factors

influencing DIY and their interplay. The literature and the analysis then come together in the discussion where they are revised and complemented. This funnelling approach, I am aware, will be initially burdensome for the reader but I hope that it will do justice to and provide a fuller picture of the topic of DIY enquiry and practice.

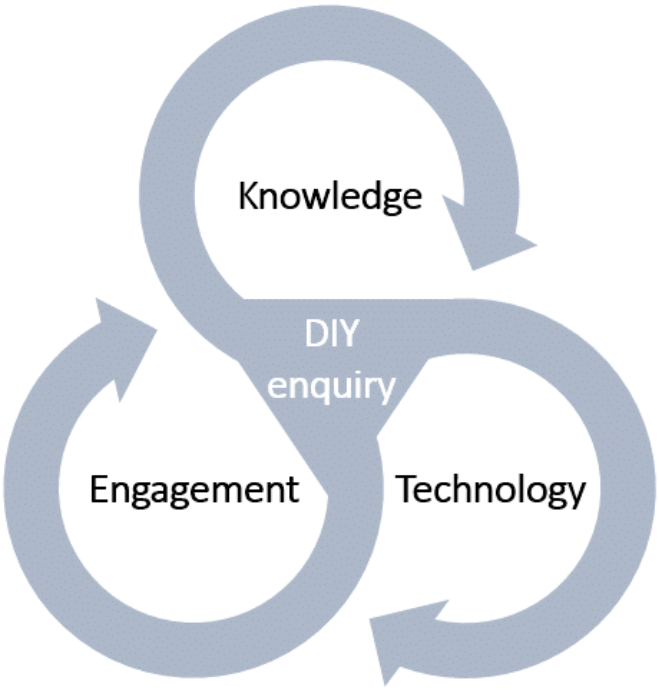


Figure 1.1: Topics central to the study of DIY enquiry

1.4 Gaps in understanding

Bottom-up and grassroots approaches to addressing local concerns have been studied in many fields. For example, from the perspective of participatory action research (Fals-Borda, 2001; Mehra et al., 2002; Whyte, 1989), critical geography (Breen et al., 2015; Crowley, 2013; Feldman, 2013), information systems (Alarcon et al., 2011; Ciborra, 1992; Sieber, 2006), development studies (Leal, 2007; McCormick, 2009; Smith et al., 2017), science and technology studies (Felt & Fochler, 2008; Foth et al., 2011; G. Ottinger, 2009), human-computer interaction (Gaver et al., 2013; Kuznetsov et al., 2012), and citizen science (Wylie et al., 2014) as for example, participatory sensing (Haklay, 2016; Paulos, 2013) and DIY biology (Ana Delgado, 2013; Kera, 2012). Many of the examples researched or cited in these studies are initiated or led by academics themselves.

Literature on processes of enquiry in technologically-oriented DIY practices that are initiated and led by the public is scant. Extant studies have focused on the recognition of 'making', as tangible, manual production of artefacts that leads to understanding of technology (Jacoby, 2013), 'hacking', as the ability to stretch and re-appropriate the functionality, capabilities, and meaning of a given system, conception, or structure beyond those prescribed by its creators (Haklay, 2013b), and 'critical making', as a way to intervene substantively in systems of authority and power and providing a space for reflecting on how such power is constituted by infrastructure, institutions, communities, and practices (Ratto & Boler, 2014a). These studies recognise the rise of communities of self-identified makers, technologists, and innovators who create and promote knowledge exchange and fabrication (Blikstein, 2013).

However, what has not been explored in current literature is the interplay between what people do with practices of DIY enquiry and what these practices do to them – cognitively and technically. It is worth clarifying these central terms, as to set the scene for the rest of the thesis. 'Cognition' here is understood as the action or faculty of knowing taken in its widest sense, including sensation, perception, conception, etc. (OED). 'Technical' refers to technical means or the use of technology (OED). 'Technology' refers to know-how (process, method, technique, and theory) as well as artefacts (including symbolic artefacts) developed from the practical application of scientific and technical knowledge (OED). Technology as symbolism is not only symbol-making and culture changing but also, in the infrastructure of daily life, it is society constituting (Misa et al., 2004).

Production and validation of knowledge has been a long and contentious topic in many fields and while it is outside the scope of this research to delve into its epistemological arguments, it is important to situate the focus on knowledge that I take. First, I adopt Certomà and Pimbert's (2013) definition of knowledge (chapter 2), which acknowledges tools, practice, and their embeddedness in culture. Knowledge is a complex process linked to the experience of making, and engaging in practice and simultaneously linked to identity formation and sense of belonging. Their definition also recognises that knowledge is created and mediated through interpretative frameworks, artefacts, and practices as people become part of a community (of practice, institutional, local, etc.). Second, this research hinges on the assumption that the recognition of multiple epistemologies is still a major barrier to inclusion and participation in science and technology. Recognition involves the acknowledgement and inclusion of multiple voices as well as the engagement of different ways of knowing, understanding, and doing (Irwin, 1995; Kurian & Wright, 2010; Reason, 2004; Smith, 2012).

Third, this research also rests on the more hopeful assumption that the 'potential' of new forms of knowledge are starting to be recognised. In their recent 'Connected Communities' project, the Arts & Humanities Research Council stresses that considerations for 'potential' (i.e. acknowledging the latent value in diversity across populations) is essential for those interested in studying production of knowledge, creativity, and innovation. Hartley (2016) argues that a rise in the use of technologies and social networks is leading to a global phenomenon of people creating new forms of association, which in turn are generating (often disruptive) interactions between them, and it is this 'newness' and knowledge produced that can potentially prove 'useful' in the future. It is important to fill our gap in understanding of what people do with/through practices of technologically-oriented DIY enquiry and what these do to them because this will help to identify, recognise, and examine the claims and standing in these practices. This can be useful to guide the creation of institutional mechanisms for more inclusive public participation in addressing social and environmental issues.

1.5 Contributions of this research

In this thesis I develop a theoretical framework (Figure 1.2) as a hypothesis that conceptualises the factors that influence practices of DIY enquiry. Hartley (2016) notes that the study of citizen-led initiatives, especially in the context of citizenship and civic action, creativity and innovation, is uncharted territory and there is currently no body of knowledge or methods that can either fully guide or to which this kind of research can contribute to.

Thus, when creating a theoretical framework for this research I drew from some of the conceptual and theoretical frameworks in the three topics covered in the literature reviews. An influential model is that of the system-lifeworld as described by Habermas (1984) and extended onto self-reliance in DIY by sociologist Wehr (2012). In this framework I conceptualise the issues of inclusion and exclusion in DIY enquiry at the individual and societal levels and the challenges these pose to DIYers and tryers of DIY. The model represents four interrelated factors. The first is the symptoms of the state as the generalisations at the societal level about publics' interests, abilities, passions and hopes held/fabricated by 'experts', society, and various publics. The second is the status of science, as the institutionalisation of expertise and the way 'science' is perceived by practitioners of science, the state, and members of the public. The third concerns issues of (self-)trust, as the

discourses and actions undertaken by the public, as individuals and groups, with regards to taking ownership over issues. The fourth is cognitive/technical mastery, as the multiple levels of mastery and mechanisms that enable contribution to and manipulation of the system.

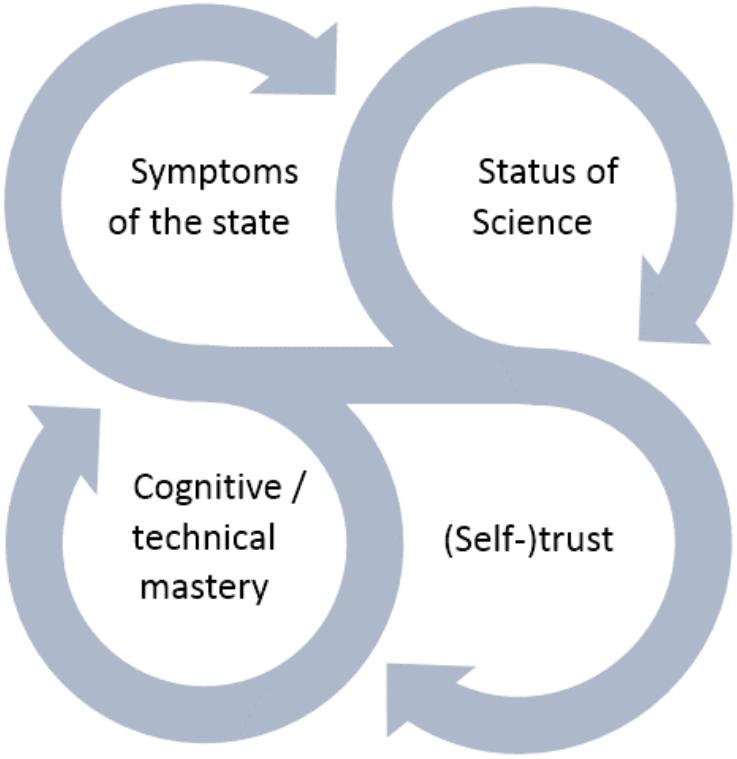


Figure 1.2: Theoretical model on factors contributing to the possibility of public engagement in practices of DIY enquiry.

This research also provides three longitudinal case studies that follow the development of technologically-oriented practices of DIY enquiry over a period of two to three years. Using a multi-method approach, these case studies explore in-depth the nature of production of knowledge, the role of technologies, and the barriers and opportunities to public engagement in DIY enquiry. They also provide an empirical basis for testing the theoretical model. Insights from these case studies yield the publication *Promoting playfulness in publicly initiated scientific research: for and beyond times of crisis* (Regalado, 2015) and the theoretical model underpinning this research was published in *Getting out of their way: Do-It-Yourselfers, sensing, and self-reliance* (Regalado, 2016).

The first longitudinal case is a participant observation of a community of DIY practice. Participant observation enables a deeper understanding of the community's inner processes and interactions, framings of science and technology, and how DIY practice is performed

through DIY tool use and development. The second case involves the design and facilitation of a DIY workshop series. The development of 'playshops' as a mode of engagement that fuses art and science with everyday life helps to identify and acknowledge how people initiate their engagement in DIY enquiry. It also helps to pinpoint barriers and conditions for engagement in DIY enquiry at the individual level. The case reveals that barriers and opportunities to engagement are mediated by frame of mind, setting, facilitation, and interactions. Research through observation of place-based citizen initiatives of DIY enquiry reveals the range of interconnected actions: development of techniques and strategies for tool development, data interpretation, and leveraging of knowledge and stance for advocacy. Together the cases reveal the transformative power of DIY enquiry, how it builds knowledge, culture, and identity and that engagement requires curiosity, courage, commitment, and foundational competencies. They also reveal an inherent tension between DIY enquiry framed as a means (seeking collective/organised actionable goals) and as an end (enabling personal empowerment).

A multi-method approach is not only necessary because of the nature of each case study but because it conceptualises the previously unexplored depths to DIY practice in a way that reveals mechanisms of exclusion at the level of the individual, the community, and place. Multi-method, Morse (2003) explains, is one in which two or more research methods are conducted, each carried out rigorously and complete in themselves within one project. Results from these methods are then triangulated to form a complete whole. However, the purpose of triangulation is not necessarily to cross-validate data but rather to capture different dimensions of the same phenomenon (Kulkarni, 2014). Mingers (2001) argues that a multimethod approach provides multidimensionality in terms of its focus and relationship to the material world (existing outside and independent of human beings but able to shape it), the social world (interactions), and the personal world (individual experiences and beliefs), one which he bases on Habermasian theory of system-lifeworld.

This work is aimed at a range of audiences. It can be of benefit to researchers of Public Engagement in science and citizen science, in particular those promoting the democratisation of science but also those seeking to work with community groups and community organisers. It is also aimed at government bodies and funders to help them better understand the emergent nature of grassroots initiatives and organisations, which is often compromised when moulded to fit the requirements of funding schemes. This research is also aimed at groups and institutions looking to build partnerships as it provides the building blocks to

inform a collaborative and purposeful partnership between government and community organisations. Above all, it is also aimed at the groups and individuals who formed part of this research by providing empirical baselines, critical analysis of practices, and frameworks that can guide practice, nurture internal/external relationships, and promote continued documentation of their work.

1.6 Thesis roadmap

This thesis follows a sequential and hierarchical structure that takes the readers through a multi-perspective literature review followed by the theoretical model which functions as a foundational hypothesis. It is followed by the methodological theory and procedures, the background and analysis of the case studies, the discussion, and ends with a reflective conclusion.

Chapter 2 provides a review of the relevant literature on knowledge to situate DIY enquiry. The chapter focuses on key research areas moving from definitions of knowledge, various epistemologies on knowledge production, the shaping of knowledge and enquiry, the uses of knowledge, and the manifestation and sharing of knowledge to then present the practice-based perspectives on knowledge that guide this research. The chapter also presents a model to situate DIY enquiry within the literature on practice-based perspectives on knowledge and knowing highlighting relevant perspectives from innovation studies and action research. The chapter offers a working definition of knowledge and ends with considerations that this research takes into account when researching knowledge production in the context of DIY enquiry and practice.

Chapter 3 reviews the relevant literature on engagement beginning with the various definitions and epistemological conceptualisations of technology. Then, arguing for a constructivist approach, it discusses the shaping of technology and its uses. It also presents a model on the social shaping of technologies based on Misa's (1992) levels of analysis and includes the factors and considerations for the study of enquiry in technical DIY. Linking to the previous chapter, it discusses technological practices in DIY focusing on DIY technologies and the challenges for DIY and grassroots technical practices. The chapter ends with a discussion on concepts and implications for DIY technologies and enquiry.

Chapter 4 is a literature review on technology. It presents definitions and conceptions on engagement and participation. Based on Friedman's (1986) epistemological model for linking knowledge to action, it reviews the epistemological concerns, purposes, political tendencies, and assumptions under which approaches to public engagement with science and technology operate, that is, 'in societal guidance' or 'in social transformation'. It focuses on citizen science and grassroots types of engagement to then present the challenges to engagement and the opportunities that it presents. The chapter ends with a model to guide the study of DIY enquiry with considerations from the literature on levels of analysis and factors influencing technical DIY. Together these three literature reviews build the content of a theoretical model that guides the initial research dimensions of the case studies and is then tested against the theoretical integration in each case study.

Chapter 5 presents this theoretical model for DIY enquiry as a hypothesis for what factors contribute to the possibility of public engagement in practices of DIY.

Chapter 6 discusses the methodological theory for this research outlining the methodological orientations, methodological tradition, and methodological design strategy taken. It begins with the development of underlying and guiding concepts used in this research. It then discusses and presents the guiding ontological and epistemological assumptions of two methodological orientations, namely sociology of technology and symbolic interactionism. Linking to the literature reviews and themes of the research this chapter lays the theoretical foundations for a multi-method approach to studying DIY enquiry. It highlights contemporary approaches to symbolic interactionism and presents the significance of a constructivist-interactionist theoretical tradition. The chapter presents the theoretical foundations of - qualitative data analysis based on the 'Grounded Theory' approach and ends with the methodological design strategy based on multiple case studies and purposeful sampling.

Chapter 7 presents the procedure of the methodology including the site selection, the methodological model, the data collection and fieldwork strategy including the procedures and tools for data collection based on the methodological theory from the previous chapter. The chapter also outlines limitations of this research.

The next six chapters present three in-depth case studies that explore the nature of the production of knowledge, the role of technologies, and the barriers and opportunities to

public engagement in DIY enquiry. The chapters are paired with one chapter presenting the background of the case and the other the case analysis. The background covers the context of the case and lists the sources of evidence analysed, including interviews, texts, etc. The analysis of the case follows the Grounded Theory approach and takes the reader through the three stages of analysis: comparative process and selection of research dimensions, theoretical sampling, and theoretical integration to develop an explanatory model specifically for that case study.

Chapter 8 and 9 present the case background and analysis of a participant observation for a community of DIY practice. Chapter 9 presents the Grounded Theory for this case study explaining how culture and practice are embedded within interactions, framings, and factors that enable and promote it. Culture and practice represent the actions, roles, and members of the community as well as the tools and infrastructure, narratives and meanings, productions of knowledge, and know-how/ skills. The Grounded Theory also portrays the relationship between culture/practice and values held by the community.

Chapter 10 and 11 present the case background and analysis of 'playshops', a DIY workshop series design and facilitation. Chapter 11 also presents a theoretical model that explains the interplay between workshop environment, personal sphere, social context, and conditions for engagement in the playshops, with a focus on the consequences of engagement and what interactions within mediate and are mediated by.

Chapter 12 and 13 present the case background and analysis of observations on place-based citizen initiatives of DIY enquiry. Chapter 13 presents the Grounded Theory for this case highlighting that stance and framing of roles plays an important part but also are shaped by the context of place. The theory also portrays the salient actions and responses taken by grassroots organisations/groups to achieve actionable goals.

Chapter 14 answers the research questions and reviews the relevance of the theoretical model presented in chapter 5 to discuss the amendments made to it based on the research findings. The chapter discusses the transformative power of DIY enquiry, how it builds knowledge, culture, and identity and how engagement requires curiosity, courage, commitment, and foundational competencies. It also reveals an inherent tension between DIY enquiry framed as a means (seeking collective/organised actionable goals) and as an end (enabling personal empowerment).

Chapter 15 concludes this thesis by examining the contributions of this research, including how it facilitates a better understanding of the democratic potential of public engagement in science in our time but it also how it promotes the leveraging of knowledge production between professional/institutional science and civil society. It reviews limitations of this study and proposes potential next steps and directions for future research.

2. Situating knowledge and enquiry

The literature on DIY is scant in comparison to the vast literature on knowledge and its production. However, numerous studies in a range of fields provide valuable insights into knowledge production, shaping, use, and sharing in the context of DIY. In this research I focus on constructivist ontologies and epistemologies (as opposed to objectivist worldviews) that can guide the understanding of knowledge in the context of DIY enquiry and practice. I explore the literature on production of knowledge and factors affecting its production, the shaping of knowledge and enquiry, uses of knowledge, and the manifestation and sharing of knowledge. I then focus in on practice-based perspectives on knowledge to shed light on the practice of DIY enquiry and the relation between action and production of knowledge.

2.1 Defining knowledge

Knowledge is defined by the Oxford English Dictionary as the action of acknowledging or owning something that is believed in from experience or association. Reason (2006) conceptualises knowledge as the multiplicity of ways of knowing and doing specifically, in people's own personal terms. He draws from Kolb (1984) who defines learning as the process whereby knowledge is created through the grasping and transformation of experience in a cycle of reflection, conceptualisation, experimentation, and concrete experience – leading to greater personal autonomy through ownership over experience (McMahon, 1999). Others argue that knowledge originates and is shaped by a consciousness of a world of everyday life (Berger & Luckmann, 1966; Habermas, 1986a) and that it supports our practice as it informs and shapes our capacity to reflect and act (Reason, 2004). That is, knowledge is a living, evolving process of coming to know rooted in everyday experiences (Reason & Bradbury, 2001,). At the same time knowledge is conceptualised as being selected and shaped by processes that reflect our values and the commitments behind them (Hannabuss, 2001; Ravetz, 2006). Dewey argued that scientific knowledge develops as a product of enquiry; experiencing the world creates facts that can be tested and organised in the mind and sense-making does not occur if "there is no balance between doing and receiving" (Dewey, 1934, p. 45). According to Piaget (1971) knowledge occurs continuously as we construe moment-by-moment what we experience. From a critical standpoint, Foucault (1970) highlights the power dynamics within knowledge production and calls for an understanding of knowledge

as situated, partial, and located. Arguing for a revolution in the aims and methods of science, Maxwell (1984) noted that knowledge is not the priority; what is needed are new ways of acting linked to a new tradition of enquiry that acknowledges and helps solve problems.

For Liew (2007) knowledge is cognition or recognition (know-what), capacity to act (know-how), and understanding (know-why). But taking it further, and in considering its materiality and its intertwining with practice, Certomà and Pimbert (2013) define knowledge as "tools, interpretive frameworks, products and practices, which constitute the social heritage that individuals acquire in their becoming part of a community and through experiential learning". This consideration for interactions and experiential learning is central to 'practice-based perspectives' (section 2.6 p.48), which hold that knowledge is situated in practice and that learning and innovation happens at the boundaries/intersections between disciplines or specialisations. Thus, knowledge is "both a source of and a barrier to innovation" (Carlile, 2002, p. 442). To understand production of knowledge and the role of knowledge in DIY enquiry and practice it is useful to look at literature surrounding 'learning', especially hands-on learning, which I explore next in terms of factors influencing production of knowledge.

2.2 Production of knowledge and factors affecting its production

2.2.1 Prior and tacit knowledge

Winter (1997) describes experiential learning as an iterative cycle of action and reflection; it is creating knowledge out of one's practical involvement and the critical examination of one's own practice. For Kolb and Kolb (2005) it is a process of constructing knowledge from the creative tension between experiencing, reflecting, thinking, and acting. They argue that immediate or concrete experiences are the basis for observations and reflections, which are then 'assimilated and distilled' into abstract concepts that inform future actions.

Unlike children, adults do not approach new situations with totally blank minds; they bring with them a wide range of experience, which some call 'prior knowledge' and 'tacit knowledge' (Collins, 2013; Hannabuss, 2001). Jain (2014) argues that memory is the central feature of prior knowledge that individuals bring to each new problem or task. Furthermore,

memory is shaped by the interconnected process of abstraction, acculturation, cognition, context, individual motivation, metacognition, perception and social group.

Rumelhart (1981, in Glaser, 1984) conceptualised the knowledge that we experience first-hand as 'modifiable mental information structures' or *schema*. Schemata are prototypes in memory of frequently experienced situations (e.g. interrelationships, sequences, consequences, etc.) and play a central role in thinking, understanding, and reasoning. Rumelhart argues that these interrelated knowledges enable individuals to make assessments, assumptions and predictions; the knowledge they infer goes beyond observations available to them because they draw from prior knowledge. Glaser (1984) states that this prototypical knowledge is often a form of tacit knowledge present in effective problem solvers and skilled learners (p.100). It is acquired over long periods of learning and experience and as individuals acquire more experience applying what they know, they gain more ability to abstract and organise knowledge (ibid).

Studying the role of knowledge in education from the psychology perspective, Glaser (1984) found that the difference between experts and novices lies in their knowledge-base, which gives experts the ability to infer from acquired knowledge. When confronted with new situations novices approach a problem by interpreting it literally. Experts on the other hand, draw knowledge from related subject matters, principles, and abstractions that surround that situation/objects. Experts not only possess 'know-how' (application of what they know) but also 'know-what' and 'know-why' as Liew (2007) suggested.

Keating et al. (1996) describes 'tacit knowledge' as the unconscious 'how-we-do-it' knowledge (e.g. riding a bicycle). Eraut (2000) argues that in non-formal learning settings tacit knowledge may be either acquired or used simultaneously. Both Keating et al. (1996) and Tanenbaum (2013) hold that spontaneity and playfulness draw from tacit knowledge but also create and organise knowledge into schema. Tacit knowledge is of interest because, as they argue, a great many of our decisions and actions are based largely on it. Eraut (2000) explains: the intuitive mode of cognition relies more on prior experience than theory or research, and makes considerable use of tacit knowledge. Even when that knowledge is capable of being explicitly described by the actor, it may be used tacitly because that is usually quicker. Keating et al. (1996) note that tacit knowledge can be made explicit through a process of reflection, dialogue, and expression. Moreover, iterations of this process reveal contradictions (between our tacit knowledge and our explicit knowledge) and this enables learning. Settings and

conditions for this process are discussed in section 2.2.3 (p.39) and together with the key aspects of tacit knowledge and reflection (next section) they begin to shape a conceptual model for the study of knowledge and its production in DIY enquiry (Figure 2.1, p.50).

In recent years several researchers have been studying the ways in which 'informal learners' become active participants in shaping their identities and culture. For example, Jenson et al., (2014) look at how informal learners use and repurpose information, consult peers, distribute and share the new knowledge generated from their informal learning activities online. In their study of DIY practices both Kuznetsov and Paulos (2010) and Jenson et al., (2014) have shown how in many cases DIY activities are not one off events but rather become informal learning communities that are growing in number with overlapping and intersecting interests – and these learning communities hold what Ross (2011) calls 'group tacit knowledge'. Continuing our examination of the process of knowledge construction in hands-on learning we move from tacit knowledge to reflection.

2.2.2 Reflexivity

Arguing for 'reflective practice' in school curricula, van Manen (1977) defines 'practice' as a process of establishing communication and common understandings. He further defines reflective practice as the process of analysing and clarifying individual and cultural experiences, meanings, perceptions, assumptions, judgments, and presuppositions, for the purpose of orienting practical actions. Reflective practice reflects on itself and questions the worth of knowledge and worthwhileness itself. It also "involves a constant critique of domination, of institutions, and of repressive forms of authority" (van Manen, 1977, p.227).

Similarly, and from the perspective of adult learning, Brookfield (1995) identifies three interrelated processes in critical reflection: a process of questioning and replacing assumptions that were once accepted tacitly as common sense; a process of accepting alternative perspectives on previously taken for granted ideas, concepts and reasoning; and a process of recognising and understanding the hegemonic aspect of values in dominant culture, alienated values of minority ideology, and the 'natural' state of the world.

Ashcroft and Foreman-Peck (1994, in McMahon, 1999) further note that reflective practice requires a commitment to learning from experience and from evidence, rather than learning

certain 'recipes' for action. They argue that as you gain reflective experience, you gain confidence to identify underlying assumptions about not only your own practice, but also the social, moral and political context for that practice.

These authors point to reflexivity on self and social contexts. They also highlight autonomy in experiential learning. McMahon (1999) further remarks on the interrelation between action and reflection and notes this as the parallel between action research and Kolb's (1984) learning cycle. These two approaches concur in that reflection is intended to be transformative. This transformation occurs at both the personal level (aimed at knowledge and attitude) and organisational level (aimed at strategically improving practice or practical actions), especially in action research (McMahon, 1999).

According to Flavell (1979), when individuals are motivated to engage in active reflection as a means of problem solving, they actively engage in critical reflection and metacognitive activities to theorise, test and evaluate new ideas. Kolb (1984) argues that as individuals continue their engagement with critical reflection they also develop resilience to engage in ill-structured tasks and the confidence to challenge existing assumptions. From the perspective of educational psychology and looking at professional work, Eraut (1994 in Eraut, 2000) notes that when there is uncertainty about outcomes, guidance from theory is only partially helpful, contextual knowledge is insufficient, and there are time pressures, individuals not only draw from tacit and explicit knowledge and rely on judgment – they also tent to consult or involve other people, moving from DIY to DIT (Doing-It-Together).

However, framing it as 'unguided learning' Kirschner et al. (2006) and Mayer (2004) critique experiential and hands-on learning in that it creates a considerable cognitive overload that tends to confuse the learner if no initial framework is available, etc., it creates misconceptions, and that when compared to perscriptive instructional designs, its measurable performance is worse for most learning situations. So where does tacit knowledge and reflexivity get encouraged and nurtured – can it?

2.2.3 Spaces for experiential learning

Gerstein (2016) and Tanenbaum et al. (2013) hold that in 'maker education' reflection should be intentionally built into the process of making, spending as much time on it as the making itself. Dougherty (2013) and Gerstein (2016) hold that maker education is about mind-set: thoughts and actions linked to creativity, innovation, ingenuity, out-of-the box thinking, and self-directed learning. Dougherty (2013) calls it 'experiential play.' Promoting 'maker education', Gerstein (2016) advices, should involve providing various media for exchange; hands-on experiential learning with learners being engaged intellectually, emotionally, socially and physically; opportunity to engage in decision making about/within the learning process; focusing on the process of creating, innovating and learning over that of production; and providing experiences that include success, failure, adventure, risk-taking, and uncertainty. She adds that in this environment the role of the facilitator moves from content expert/deliverer to one of lead learner.

Kolb and Kolb (2005) concur and argue that learning requires facing and embracing differences; coming to terms with conflict, differences, and disagreement are what drive the learning process and is the process of adaptation to the world. They note that learning is not just the result of cognition; it involves the functioning of a person as a whole: thinking, feeling, perceiving, and behaving. Confronting tensions can be challenging and threatening (Brown, 2010) and requires a learning space that encourages the expression of differences and the psychological safety to support the learner in facing these challenges (Gerstein, 2016; Kolb & Kolb, 2005; Tanenbaum et al., 2013).

Complementing Gerstein (2016), Kolb and Kolb argue (2005) that this state of vulnerability requires creating and holding 'safe learning spaces' that have a culture of support. They also note that emotions influence learning and memory; feelings and emotions have primacy in determining whether and what we learn (p.208). Acting as barriers to engagement, negative emotions such as fear and anxiety can block learning, while positive feelings of enthusiasm and interest may be essential for learning (Geoghegan et al., 2016; Reason, 1999). Therefore, when designing spaces it should be considered that "people grow best where they continuously experience an ingenious blend of challenge and support" (Kegan, 1994, p. 41).

The creation of spaces for hands-on experiential learning is not a new idea; it can be traced back to progressive education theorists (e.g. Dewey, 1910; Freudenthal, 1973; Montessori,

1964; von Glasersfeld, 1984) and critical pedagogy scholars (e.g. Freire, 2000; Horton et al., 1990; Papert, 1987), who advocated for providing environments in which learner's interests/passions can thrive. Piaget (1971), for example, claims that the construction of knowledge happens remarkably well when students build, make, and publicly share objects because exposure promotes exchange and learning. The continuity and creation of a space for 'making' is important because it can foster the several cycles of design and redesign needed in a project. A space also provides the opportunity to face (alone or in groups) new and intense experiences of failure – but in 'safe spaces', where relationships with mistakes can be reimagined (Blikstein, 2013; Firestein, 2012). We now move from factors affecting enquiry to how it is shaped – epistemologically and in practice.

2.3 Shaping of knowledge and enquiry

Scholars supporting *perspectivism* (e.g. Nietzsche (1968) and Rorty (1997)) contested the notion of objective or absolute truth. They argue that there are multiple ways to perceive the same phenomenon or object; truths or knowledges are merely points of view. Similarly, in *hermeneutics*, supported by philosophers and thinkers such as Heidegger (1988), Gadamer (2008), Habermas (1986a), and Geertz (1986), knowledge and meaning are a type of narrative that is always open to new interpretations. From a constructivist perspective Trevor and Pinch (2011) maintained that scientific knowledge is thoroughly socially constituted and they boldly expressed that

> the treatment of scientific knowledge as a social construction implies that there is nothing epistemologically special about the nature of scientific knowledge: It is merely one in a whole series of knowledge cultures (p.12).

Some of these conceptions link back to Durkheim (1895), who posited that knowledge emerges from socialised, encultured, and educated brains. These educated brains share concepts such as status, roles, culture, language, values, social practices, and patterns of behaviour. Durkheim conceptualised this as intersubjective 'social reality' (also known as *structuralism*). Durkheim and other social theorists contend that *social reality* manifests itself as both the 'choices' we make and the impacts of these choices on our environments. However, Foucault (1970) argues that knowledge is not separate from power; many 'free' choices are made by individuals as a result of internalised knowledge structures in the communities and societies within which they operate. Kuhn (1962) argues that researchers operate within

paradigms that use exemplars, languages, conceptual systems, and value systems that inform members how to do 'good science'. He argues that these scientists work within the system (or 'normal science') and perpetuate it rather than trying to overthrow its paradigm or its assumptions.

Following from this, Lynch (2004) argues that the positional labels of 'expert' and 'scientist', are membership categories created, reproduced, and perpetuated in conventional associations through 'institutionally embedded' interactions. These interactions are in turn mediated by discourse embedded in and equally perpetuated by institutional practices. In the context of DIY practice the boundary between expert and non-experts is of interest because it prompts questions about who decides the labels and their meanings/uses; how are particular individuals assigned to a category; and how does this mediate interactions in DIT? According to Ottinger (2013), the meaning assigned to these labels defines people's roles – not merely for self-definition but to portray it to others to gain power, control, and even trust, subduing others' claims. Consequently, labels such as 'amateur' and 'lay', can be seen to 'other' or discriminate non-specialists while reinforcing and perpetuating a hierarchy in knowledge.

This is linked to the issue of 'validity'. Validation of knowledge implies a validator and a set of 'criteria' against which knowledge is 'authenticated' (Friedmann, 1987). Therefore, if treated as a social product, knowledge requires a consensual basis; people who find no one to agree with them are pushed to the margins (ibid). Jasanoff (2004) and Tanenbaum et al. (2013) suggest that co-production of knowledges and creation of artefacts requires both the stability of trust (that comes with organisational structure and infrastructure to support efforts) as well as faith in uncertainty and sharing a vision for change. Therefore can it be said that it is this trust and higher level of comfort with uncertainty (which is at the heart of DIY culture) that provides foundation for consensus and validity. There is evidence of this in the value that communities of DIY practice place on peer-production for validation and a movement from DIY to DIT (Hartley, 2016; Ratto & Boler, 2014b).

But how are enquiry and knowledge shaped in DIY? Friedmann (1987) and Irwin (2006) note that while professional science employs strictly enforced and formalised processes of validation, political arenas have few rules of discourse and thus, knowledge is validated based on management of power – or the perception of it. However, while DIY (especially in environmental monitoring) relies on science techniques, it is also political in several ways.

Kulle (2013) and Levine and Heimerl (2008) list them: in the economic dimension through self-reliance; in the subjective dimension by prioritising agency and emancipation (e.g. questioning professionalisation); and in the social dimension by being more socially inclusive with smaller groups (e.g. lacking gatekeepers). Additionally, in some DIY practices there seems to be an inherent tension between abiding to the establishment and questioning it (Brass & Koziell Poklewski, 1997; Morozov, 2014). At the same time, DIY is often torn in a dialectic between emancipation and normalisation (Ratto & Boler, 2014a), which I discuss further in the next chapter on the role of technologies.

This literature highlights the simultaneous contribution of various perspectives such as constructivism and structuralism to the understanding of sociotechnical practices of DIY enquiry. Thus, when trying to understand the factors that contribute to the potential of DIY practices it is important to consider as Chidgey (2014) suggests, the way that DIYers internalise and externalise the social norms and values of both the social group in which they engage as well as the structures that socially, politically, economically motivate and shape them. Or as Jenson et al., (2014) stipulate: we need to understand the extent to which autonomous individuals are "able to critically self-regulate in accordance with social metanarratives and external authority within a heterogeneous society" (p.161).

2.4 Uses of knowledge

How is DIY enquiry and DIY practice used? Numerous examples on the web point to the demystification of technologies (e.g. to show that they are not exclusive to professionals), the provision of political counternarratives (e.g. maktivism (Mann, 2014) and DIY performance (Daniels, 2015)), ways to remake and reimagine problems and solutions (e.g. instructables), etc. Current literature on DIY argues that citizens assume active roles as interventionists, makers, hackers, and tinkerers, in pursuit of new forms of civic engagement and participatory democracy (Heimbuch, 2012; Ratto & Boler, 2014; Wylie et al., 2014). Descriptions of the uses and applications of DIY practice are characterised by self-sufficiency, making, and ownership, epitomised by the now ubiquitous quote "if you can't open it, you don't own it" (Jalopy, 2005). The Wikipedia entry on 'DIY ethics' highlights a political autonomy and empowerment:

> [DIY] promotes the idea that an ordinary person can learn to do more than just what he or she may have thought was possible. [...] A DIY attitude requires that the adherent attain as well as retain the knowledge required to complete a given task. Without this, DIY is an ineffective dogma. [...] Central to the ethic is the empowerment of individuals and communities, encouraging the employment of alternative approaches when faced with bureaucratic or societal obstacles to achieving their objectives. [...] DIY champions the average individual seeking knowledge and expertise for him/herself.

This links to Kulle (2013) and Levine and Heimerl's (2008) examples of DIY as political practice mentioned above. Similarly, other publications entice a move from passive to active engagement: "understanding brings knowledge, and with knowledge comes the power to make decisions that can change our lives for the better" (Gertz & Justo, 2012, p. ii) and "community is the seedbed of democracy, where ordinary people are able to discover that they have extraordinary abilities to get things done in concert with other people" (Clegg et al., 2006, p. 75).

Critical perspectives on knowledge have long highlighted the plurality of knowledge, as discussed above. Boaventura (2007) and Visvanathan (1998) argued for the right of the different forms of knowledge to co-exist. They called it *cognitive justice*. It is a useful perspective for understanding DIY enquiry, because as Bhattacharyya (2004) and Friedmann (1987) note, dominant approaches frame disparity in terms of powerlessness, which often justify the need for external institutional intervention and reform. Dominant framings often objectify people's needs and ignore, to varying degrees, their potential, their hopes, their knowledge, their assets. I discuss this further in chapter 5, where the theoretical framework is presented.

Power and empowerment emerge as key themes in the study of citizen-led initiatives and are clearly linked in the literature to identity, meaning, and the importance of working together. According to Dunbar-Hester (2014) many technologically-oriented DIY activists seek to produce not only technological artefacts but also egalitarian social relations that purposefully erode the boundaries between experts and 'lay people'. She theorises that activists draw a connection between the 'maker agency' that they attain through tinkering and a political identity that inclines them to not only build technical capacity but also participate politically (Dunbar-Hester, 2014, p. 77). She explains further:

> In essence, [activists] promoted a version of technical identity that connected political agency to technical work. In this way, 'maker' was a way of being in the world, with distinct political implications. They emphasised making as a form of empowerment because of its potential to undermine social order in which technology is esoteric and

> intelligible only to experts; thus critical making was linked to a general notion of social participation (p.78).

Dunbar-Hester (2014) further notes that in these makers' conception of the agency 'technical identity' was not necessarily the same as 'technical skill' because they valued technical participation and demystification over virtuosic expertise. This example helps to conceptualise identity and meaning in the use of knowledge. This is in line with the way knowledge pluralists (who reject the idea of only one truth, knowledge, or way knowing) conceptualise identity as the outcome of cultural and collective processes and the product of group-made knowledge (Johnson, 2008).

Dunbar-Hester (2014) reminds us that DIY tools and techniques do not in themselves address issues. However, they do help people ask questions and make issues more visible (Gertz & Justo, 2012). As Jenson et al. (2014) and Kelty (2005) point out, they provide a powerful means of conceptualising and facilitating civic action that reimagines public engagement and citizen-led enquiry. Practice-based perspectives on production of knowledge also provide useful conceptions to explore DIY enquiry. For example, Carlile (2004) and Swan et al. (2007) explore collaborative innovation and conceptualise the issues that arise between areas of expertise where there is great potential for productive exchange but also tension. These conceptions, explained further in section 2.6 below, highlight key aspects in the use of DIY enquiry: common lexicon, meanings, and interests that when in place, can promote knowledge sharing. Action research also provides useful conceptions highlighting different ways of knowing and doing (also discussed below).

An additional conceptualisation for DIY enquiry and practice is that of the 'maker'. In singular form, while possibly reflecting/upholding a Western worldview and bias for individualism, it points to particular individuals or 'champions' who become capable of self-determination having challenged traditional norms and who develop a self-awareness of being distinct from social groups (Wehr, 2012). For example, in Douglas' (2016) study of DIY urbanism, DIYers make use of both technical knowledge (including familiarity with city policy, development history, planning practice, and professional tools, materials, and technical know-how) and scholarly knowledge (such as urbanism, critical urban geography, and broader planning and development theory) to taking matters into their own hands. They do it with the skills and knowledge that reveals how they combine it with an awareness of formal planning and design contexts. This knowledge not only informs their civic actions, it also gives them confidence to assert that what they are doing is the right thing for the city.

The assumption here is that it is these individuals who develop critical thinking skills that enables them to move beyond dominant social norms, create a personal 'social reality' and ethos, operate and negotiate within the social rules, contracts and governance structures, and who are able to inspire others, as suggested by Jenson et al. (2014) and as the Wikipedia entry on 'DIY ethics' states.

2.5 Manifestation and sharing of knowledge

2.5.1 Tensions in 'expert knowledge'

How are knowledge and enquiry manifested in DIY? Ratto and Boler (2014b) place DIY practices at the intersection of several tensions: between individuals and communities, professional expertise and amateurism, and governments' idea of democracy and politics versus the democratic and political ideals of grassroots initiatives. These tensions are manifested in the phenomenon of 'institutionalisation of expertise' (Beer & Lewis, 1963; Freidson, 1986). On the one hand, the normalisation of expertise is said to have brought efficiency in knowledge transfer (e.g. business and military) (Jardine, 2013). On the other hand, when production of knowledge and expertise are institutionalised and guarded by gatekeepers that dictate what is and is not valid, the public's engagement in decision-making and problem-solving is compromised (Regalado, 2016; Ross, 2011). I expand this in my theoretical framework (chapter 5). However, Collins (2014b) argues that a distinction between 'expert' and 'lay' knowledge is a valid one, that certain kinds of decisions rightly belong within the realm of professionals. He explains:

> [I]t is important to understand the difference between the knowledge of experts when they make assessments of technical value and the knowledge of non-experts; the position being advanced here is that technical judgements are the prerogative of experts and it is only the consequences of those judgements that are the prerogative of non-experts. But it is easy for the two kinds of judgement to become mixed up, with non-experts believing that it is possible for them to make technical judgements. One of the reasons that non-experts might, in good faith, think they can make technical judgements that differ from those of experts is that the scientific literature, including that version of it that can be readily found on the Internet, gives the impression of being technically empowering (p.2).

A recent study by Scharrer et al. (2016) confirms this, warning that when science is presented simplistically, it inclines laypeople to underrate their dependence on experts. Collins' (2014b)

position on expertise is that "the unqualified are rarely in a good position to make such technical contributions" (p. x). For Collins 'lay' people might feel that now that they have access to technical knowledge and that they have 'informed' themselves, they can have the same standing in decision-making as professional experts with specialised technical knowledge. It is easy to see how professional experts would embrace the former position. In previous texts Collins (2014a) more humbly distinguishes between those who have expert/professional knowledge and those who can act as interpreters or intermediaries of that knowledge. The latter can move between 'knowledge boundaries' or disciplines. He argues that these intermediaries begin to master and understand some of the more elusive tacit knowledge on which expert knowledge and practice are based and which is not readily available to non-experts. However, Collins takes the distinction between different knowledges for granted and thus, fails to question why those divides are there in the first place. Because of his focus on 'professional expertise', he also fails to acknowledge expertise gained through hands-on (and informal) learning.

Wynne (2009) contrasts Collins' and other similar positions. For Wynne, these positions have a limited scope, which only asks 'what forms of 'expertise' can publics of various kinds be deemed to have, and for which they have rights of recognition?' He argues that these scholars taking these positions have taken for granted the definition of science and therefore its normative constructions of publics too. In addition, the way the difference between public and expert views are framed, he argues, have revolved around 'quality' of knowledge and the binary difference of 'expertise' or its lack, rather than around the dimensions of contested meanings, concerns, relationships, forms of life, "and thus, of what is deemed relevant" (p.23). He further links this to the denial of legitimate difference at the institutional-scientific level; he remarks: "publics know better than you think they do" (because of their experience of being and knowing) and "they know some salient things better than you" (pointing to ontological difference) (Wynne, 2009, p. 28). He highlights how multiple knowledges, which reflect the public's different sets of priority concerns, are usually prominent and urges that these be "respected, accountably validated as far as possible, and if necessary (but unity or consensus should not be presumed) negotiated together as such" (ibid).

As seen from the review of the literature thus far, power and empowerment emerge as key themes in the study of citizen-led initiatives. Dunbar-Hester (2014) and Heimbuch (2012b) defend that many technologically-oriented DIY activists seek to produce not only technological artefacts but also egalitarian social relations that purposefully erode these

boundaries between experts and 'lay people'. But 'expertise' also manifests itself within DIY communities. Through open sharing and feedback DIY communities provide their own mechanism for validation and a 'field of experts' who recognise and validate innovation (Bauwens, 2010; Kostakis et al., 2013). The 'field of experts' in DIY communities consists for example, of hobbyists and enthusiasts who critique and learn from others' work, and thus over time, give rise to the 'expert amateur'. Kuznetsov and Paulos (2010) argue that sharing is the fundamental process that drives and validates DIY creativity – but they not only share, they also assess (and therefore validate) each other's knowledge (Carlile, 2004).

Other researchers of DIY have found that the rich social spheres and mediated interactive environments where DIY makers engage in experiential learning give rise to individuals who take on roles as facilitators and who encourage and guide others (Dunbar-Hester, 2014; Fischer & Shipman, 2011; Jennett et al., 2016). Following from section 2.2.3 (p.39) on spaces for learning, these rich environments are described as flexible, heuristic, inherently transdisciplinary, supported by peer based learning, and taking place within communities of interest outside formal institutions (Jenson et al., 2014). In these spaces individuals become 'experts' through the creation of content as well as community building, and learning becomes embedded in the act of sharing as Kuznetsov and Paulos (2010) argue. However, how these environments form, what factors contribute to its existence (or not) and, what happens to DIYers in different stages of their engagement, including how they first come to be involved, remains understudied. Research on child development (as applied to DIY) and hacking shed some light on this latter point.

2.5.2 Insights into the initial stages of knowledge production through DIY

Jenson et al., (2014) describe hacking as an autonomous, self-determining learning that is deeply rooted in early childhood experiences of open ended enquiry, theory building, testing, and reflection; it is how children learn about the world. Defined as an *action*, hacking is about altering a pre-existing situation to produce something new, supporting people working together, and sharing knowledge (Haklay, 2013b; Jenson et al., 2014). Conceived in terms of *culture* it constitutes a significant component of the maker identity that encourages collaborative creation while adhering to certain ethical values such as privacy and equality (Coleman, 2012; Jenson et al., 2014; Thomas, 2003). I return to this in chapter 5.

Jenson et al., (2014) note that children explore physical knowledge, build theories about the world based on this knowledge, test the theories they create, reflect on the outcomes of their tests, and then repeat the process with new variables and/or with ever increasing levels of complexity. They also learn from mistakes and messes and how to confront authority (or gain the ability to hack social norms) (Bilandzic, 2016; Ito et al., 2009; Jenson et al., 2014). It is in these initial stages of engagement that children experience, for the first time, what Jenson et al. (2014) call "a modest form of rebellion against parental and institutional heteronomy" (p.162). It is in this way that children begin to cultivate personal awareness, self-esteem, trust in their abilities and hence, a sense of autonomy. These characteristics are similar to the competencies of successful social entrepreneurs found by Sherman (2011): optimism, grit, creativity, innovation, and resilience in the face of adversity, challenges, and failures.

It seems that if stimulation and freedom to explore is sustained over a child's development, their engagement gives rise to reflective enquiry – wondering 'what would happen if…? This, Jenson et al. (2006) claim, represents an initial point of enquiry that aids children to pose problems and enrich their ability to make informed and educated choices to tackle them. This links to Ashcroft and Foreman-Peck (1994, in McMahon, 1999) and Douglas' (2016) arguments about confidence building as children develop both self-reliance and ability to self-criticise, which are necessary conditions for engagement in the DIY practice of 'critical making' and innovation. But how do these key notions actually look like in practice? I turn to this next.

2.6 Practice-based perspectives on knowledge

DIY is the act of creating; it enables makers to appropriate, encode and reproduce knowledge that is directly relevant to their own lives. For Jenson et al. (2014) and Tanenbaum et al. (2013) this encompasses, in part, DIY practice. Ratto and Boler (2014b) describe 'critical making' as a practice that provides the possibility to intervene substantively in systems of authority and power. While a clear conceptualisation of elements/processes constituting critical making is not explicit, Ratto and Boler (2014b) argue empirically that it offers individuals and groups an important space for reflecting on how power is constituted by infrastructure, institutions, communities, and practices. Therefore, understanding and conceptualising the relationship between action (including making), production of

knowledge, and artefacts is essential to gaining insights into practices of DIY enquiry – what do these do to DIYers and what do DIYers do with them? Jenson et al., (2016) look at how the practice of DIY enquiry (questioning and looking for alternatives) moves people from being passive receivers of information to active agents in the creation of multimodal[3] forms of knowing. Similarly, but from an action research perspective, Reason (1999) proposes 'cooperative enquiry' as a way for a group of people sharing similar interests in understanding the world to make sense of it and develop new and creative ways of looking at things to bring about change.

Practice-based perspectives on knowledge production provide useful concepts to study DIY practice and enquiry. I explore three frameworks: social construction of reality, knowledge boundaries, and ways of knowing, shown intertwined in Figure 2.1.

Berger and Luckman (1966) proposed the conception of knowledge and production of knowledge as a process embedded in the everyday practices shared among ordinary people. Their model of externalisation, objectification, and internalisation introduces the 'social construction of reality'. Briefly described, *externalisation* is the creation of culture and practices by acting in the world; *objectification* refers to the actual realisation (objectification) of social knowledge through actions and beliefs; and *internalisation* is when beliefs become taken for granted (the ideas of cultures and subcultures) and seem natural, instinctive, justified, and right. Internalisation operates through socialisation and other forms of social control such as formal and informal laws, peer-pressure, punishment, etc. This position on knowledge provides the foundations for other theoretical approaches such as Symbolic Interactionism, which I expand on in the methodology chapter.

Carlile (2004) advances a three-level knowledge boundary model for understanding the requirements and barriers for knowledge production and sharing in the context of innovation. He explains that at a *syntactic boundary* between two areas of knowledge/disciplines practitioners develop a common lexicon to transfer knowledge and it is sufficient to share and assess knowledge, its relevance, use, etc. (e.g. experienced users retrieving information from GitHub). Here the common lexicon plays a key role but is not always sufficient or adequate to convey information or represent the differences in

[3] Multimodal refers to the different ways that people interact with technologies – capturing, adapting, sharing, and interpreting with various physical and digital artefacts.

understanding that arise from the use of the transferred knowledge. This lack of common reference points leads to the next boundary.

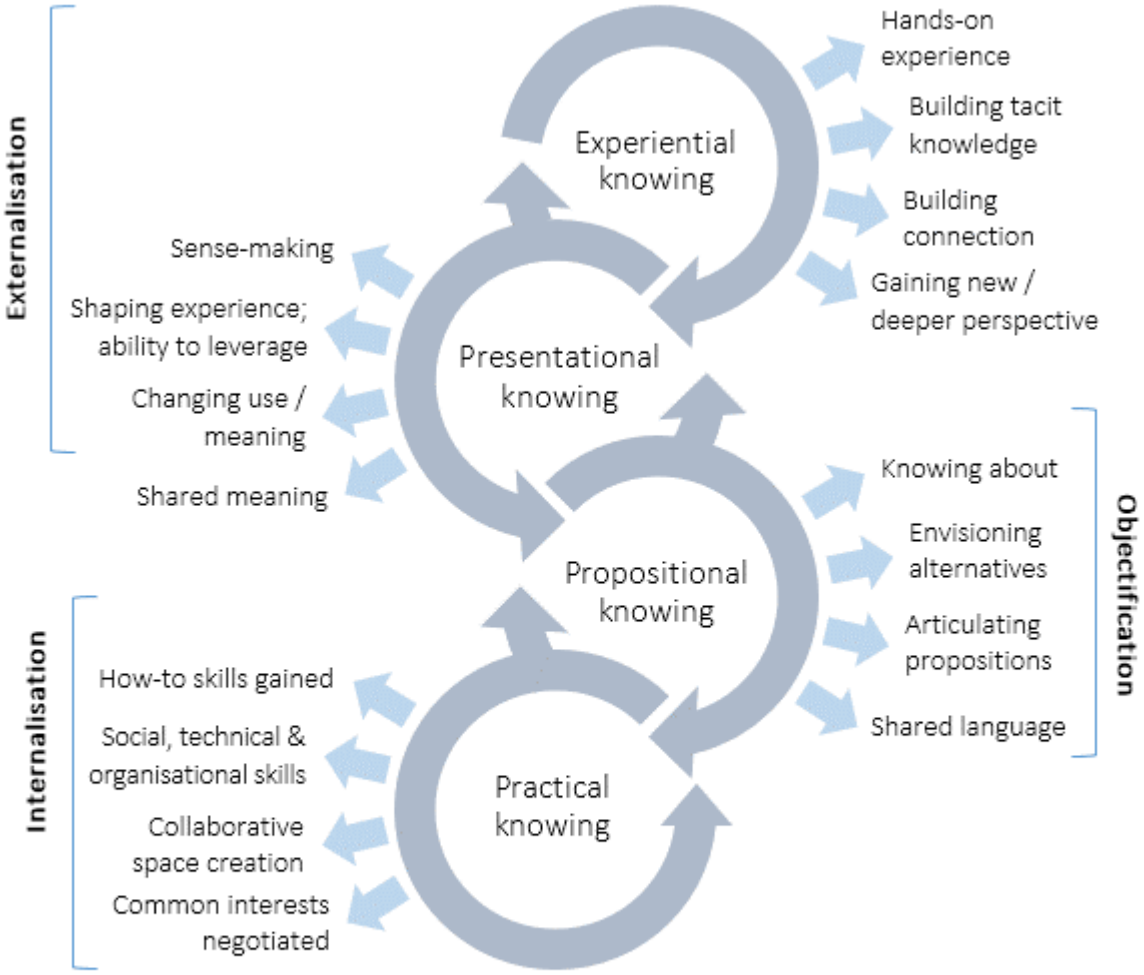


Figure 2.1: Modelling the literature on practice-based perspectives on knowledge and knowing to guide the study of DIY enquiry

At a *semantic* or *interpretive boundary* the challenge is to create common meanings that enable sharing and assessment of knowledge. Here, the participatory and relational nature of what a practitioner/actor needs to share and assess is not well known. This generates differences and dependencies and raises the potential for multiple interpretations (creating both tensions and opportunities). Some argue that this often requires creating new roles and organisational/group arrangements e.g. the rise of knowledge brokers who translate or facilitate the flow of knowledge or the use of common methodologies, templates, or platforms (Collins, 2014a; Meyer, 2010) However, Carlile (2004), notes that interpretative approaches to understanding practice-based perspectives are limited in scope as they only

focus on meaning and therefore "do not specify processes that deal with different interests and their political consequences" (p.559). For example, these do not recognise that in the course of making one's own tacit knowledge explicit, different interests are often revealed. They also do not account for how these may create barriers to developing shared meanings. Hence, when creating shared meaning is not possible, "what is required is a process in which actors negotiate and are willing to change the knowledge and interests from their own domain" (p.559). In other words, when different interests arise, developing an adequate common knowledge is a political process of negotiating and defining common interests. This leads to the next boundary.

At a *pragmatic or political boundary* the focus is on the negotiation of practice. It requires significant practical and political effort – in not only enabling the taking up of another perspective but to create a new shared perspective (Brown & Duguid, 2001; Carlile, 2002). Here boundary objects play a role of in transforming knowledge to create shared meaning and common interests. For example, co-developing prototypes, helps to build the capacity to negotiate interests and transform knowledge, which gives ownership over co-creation of knowledge and meaning (e.g. Baljko & Hamidi, 2014; Fischer, 2011).

This sense of ownership can be conceptualised through the model of ways of knowing in action research. Heron and Reason (2008) propose an extended epistemology of experiential, presentational, propositional, and practical ways of knowing embedded in cycles of action and reflection (p.366). Ways of knowing are the everyday concerns that shape and nurture people's processes knowledge production through interactions, enquiry, and sense-making.

Experiential knowing, represented by the first loop in Figure 2.1, is the perceptual awareness from being in direct face-to-face contact with a person, place, or thing. It links into Berger and Luckman's (1966) *objectification* as people begin to create culture and practices.

Presentational knowing grows out of experiential knowing; it is the way we make sense of our experiences and give them shape in non-discursive ways. It is a way of telling the story of our experience through DIY, as Wylie et al. (2014) relate: it is re-describing stories of what is, who can do, and what it means to do. This is parallel to *objectification* and it also represents the creation of common meanings (Carlile, 2004) shared non-discursively. These links are represented in the second loop in Figure 2.1.

Propositional knowing is 'knowing about' and it is expressed in intellectual terms: ideas and theories as propositions which use written or verbal language to assert laws or facts. It is the process of redrawing perspectives and envisioning alternatives. Still in the realm of objectification, it also represents the creation of a shared lexicon expressed in verbal/written form.

Practical knowing is knowing 'how to' do something and it is expressed in a skill, knack, or competency. Continued learning and use of knowledge builds experiential and tacit knowledge and therefore *internalisation*. Through cycles of enquiry (represented by the reverse arrows in Fig 2.1, especially at the community-level of enquiry, propositional knowing is tested in practice and fed back into experiential and presentational knowing (Heron and Reason, 2008). An extended discussion of these is presented in Appendix E.1. These cycles give focus and clarity in transferring learning from previous action cycles to fruitful planning of the next. But as Carlile (2004) reminds us, in collaborative practical knowing and organisational building there is also continued negotiation of interests and ways of moving forward.

2.7 Situating knowledge in DIY enquiry

Hartley (2016) notes that the study of citizen-led initiatives, especially in the context of citizenship and civic action, creativity, and innovation, is uncharted territory and there is currently no body of knowledge or methods that can fully guide or to which this kind of research can contribute to: the study of DIY practices necessitates a new conceptual remix.

The ideas reviewed here are not new: Dewey's conception of iterative enquiry, Foucault's critical enquiry, and Berger and Lukemann's everyday knowledge have guided their contemporaries. However, to understand the highly personal and experiential context of DIY enquiry in both social and technical senses, we need to also grasp the unique nuances of knowledge production in DIY: knowledge is deeply embedded in practice and there are multiple pathways and contributions to knowledge creation – some of which are not always apparent.

Certomà and Pimbert's (2013) definition of knowledge (section 2.1, p.34) acknowledges artefacts and their concomitant techniques acquired and developed through interactions that are embedded in and build culture. Their definition points out that knowledge is created and

mediated through interpretative frameworks, artefacts, and practices as people become part of a community (of practice, institutional, local, etc.). It also points out that knowledge is a rich process linked to identity formation and sense of belonging (echoed throughout texts on DIY). Together with conceptions in practice-based perspectives, their definition also points to the role of technologies in knowledge production in the context of DIY and grassroots initiatives. This is the topic of the next chapter but here it is important to note that social theories have tended to ignore the role of technologies (Misa et al., 2004). Technologies are an important aspects of DIY making and practice: e.g. the multiplicity of technologies developed and used in DIY and grassroots initiatives proliferate and provide different ways of capturing, sharing, telling, and representing stories through personalised codes, filters, and algorithms. Practice-based perspectives can help to conceptualise practice and meaning but the need for complementarity by literature on technologies is clear.

Johnson (2008) argues that there is no 'best' approach to conceptualising knowledge: "social constructivists are right that we construct social thought, but the 'scientific' structuralists also are right that we are born into structures that help make us what we are" (p.482). That is, human freedom can exist within structures, while individual perspectives help determine personal identities, experiences, and schema. Furthermore, for a more cogent and comprehensive conception of knowledge, he concludes that what is considered to be 'knowledge' changes over time and therefore it is important to consider and carefully analyse how knowledge, as a conception, changes meaning as it operates in different contexts, hence, "knowledge needs to be indexed to time, place, and culture" (Johnson, 2008, p. 482).

3. Situating technologies

The use of technologies in DIY has been studied from a range of fields – from HCI to Development Studies. In this chapter I begin by exploring the several definitions of and perspectives on technology that can guide an understanding of DIY enquiry and technical practice. This leads onto conceptualisations of DIY that shed light on different tensions within technical practice. This is followed by an analysis of factors affecting development and use of DIY technologies. The chapter ends with some challenges for DIY practice and concepts that can help to situate DIY enquiry and technical practice within the literature. The chapter also offers a model to guide the study of DIY technologies.

3.1 Defining technology

The OED defines technology as a) the branch of knowledge dealing with the mechanical arts and applied sciences; b) the study of this; c) the application of such knowledge for practical purposes; d) the product of such application as technological knowledge, know-how; process, method, or technique but also machinery, equipment, etc., developed from the practical application of scientific and technical knowledge. These definitions point to the conceptual, material, and applied forms that technology takes. In a deeper analysis Misa (1992) offers a useful categorisation of the approaches to defining technology: as a type of knowledge, as a series of empirical examples, as defined formally or explicitly, as relationships between the material and human worlds, and as symbolism. The usefulness of these categories, which I explore in turn, lies in that it reveals the position/tradition of analysis, and premises of the perspective, while helping to situate and guide an analysis of DIY technologies.

The first categorisation, *technology as knowledge*, is vast and outside the scope of this thesis to detail. However, two aspects are relevant for the analysis of DIY practice. First are the different levels at which 'technology as knowledge' is conceptualised: individual, organisational, and social. For example, at the individual level it can be a special form of tacit or 'technical knowledge' (see section 2.2.1, p.35), a practical know-how rarely formalised or recorded comprehensively (Collins & Evans, 2008; Keating et al., 1996). At the organisational/social level, for example there is a call for an epistemological pluralism in

technology that recognises different ways of doing and thinking across disciplinary/practice boundaries (Carlile, 2004; Turkle & Papert, 1992). Technologies as knowledge operating at the societal level are conceptualised as enmeshed in the fabric of nearly every aspect of life, including the ways we understand what it means to be human (McChesney, 2013); technological practices are never isolated from socio-economic contexts or preceding technological practices (Mcluhan & Mcluhan, 1992). The second, relevant aspect of 'technology as knowledge' is the debate about 'technology as applied science', which again, is too wide to cover here but some perspectives are useful to raise some questions about DIY practice. Gardner (1994) outlines four science-technology positions: science precedes technology (technology is applied science); science and technology are independent; technology precedes science (historically and ontologically); and technology and science engage in two-way interaction. Supporting the first, Bunge (1966), philosopher of science, made his point clear: practice is one of the sources of scientific problems, the other is sheer intellectual curiosity; scientific ideas have been the main motor and technology their beneficiary. From a history of science perspective, Staudenmaier (2001) refutes technology as applied science arguing that science is but "one sort of epistemological equipment among several" (p. x). Others refute it on the basis that technical activity has preceded the mere existence of science by thousands of years (Gardner, 1994; Jardine, 2013; MacGregor, 2011). Gil-Perez et al. (2005) further note that the science-technology conflation (technology as applied science) is historically rooted in the unequal appreciation of intellectual and manual work as well as the conception of science as decontextualised, neutral, empiricist-inductivist, elitist, and practiced individualistically. Some scholars argue that a science-technology conflation not only ignores their epistemological differences but also takes for granted (and reinforces) power structures and the domination by a scientific worldview (Certomà & Pimbert, 2013; Gil-Pérez et al., 2005; Smith et al., 2017; Stirling, 2005). This debate forces the question: Why is that most references to DIY (popular and academic) evoke 'technologists' and 'tinkerers' (etc.) and less so 'scientists'? Is it because it is the dominant perspective of 'Science' which DIYers are rebelling against? Is it because 'technology' evokes and/or accommodates a wider range of epistemologies than does the rigid, canonical, and singular epistemology of 'Science'? I will return to these questions in the discussion, Chapter 14.

Misa's second way of defining technology, through *empirical examples*, illustrates case by case scenarios. Misa (1992) argues that this is a problematic approach because it is left to the readers to extract their own definitions. It also creates tension between those who support

and those who oppose technological determinism (philosophy that argues that technology follows its own developmental path without human influences, and thus, influences society). For example, some criticise constructivists for not holding technologies and technological change more accountable in their empirical studies (Winner, 1993; Wyatt, 2008).

The third category, formal or *explicit definitions*, abound and are often premises of arguments about broader issues or goals. For example, Hughes (1989, in Misa, 1992) contends that technology is the effort to organise the world for problem solving so that goods and services can be invented, developed, produced and used (e.g. Google or Wikipedia, as 'neutral' and 'canonical' body of shared knowledge). Other definitions speak to the 'purposeful manipulation of the material world in a useful way'. However, these normative premises beg the questions 'manipulation for whom', 'by whom', and 'who is to judge which is a useful way'? Definitions from a critical perspective are explicit on their standpoint on technology. For example, from an Science, Technology & Society (STS) and History of Technology (HoT) perspective, Hecht (2001) coined *technopolitics* to explain the "strategic practice of designing or using technology to constitute, embody, or enact political goals" (p.256). In this definition she aims at shifting the *politics* from the artefacts to those exercising power.

Stemming from the perspective of Philosophy of Technology (PoT), Misa's fourth approach to defining technology is by examining the *relationships between the material world and the human world*. In reference to large-scale, complex sociotechnical systems, Misa (1992) explains that "we do not use technologies so much as live them" (p.6); he quotes Winner (1986b): "technologies are forms of life" and life would be unthinkable without them (p.11). At the individual scale it links to Mann's (2014) DIY approach to understanding computers by living as one. This fourth approach is akin to 'technologies as knowledge' conceptualised at the societal level; and is seen as increasingly true as we become 'interffiliated' members of the flows and logics to the digital world (Castells, 2000; Ratto, 2014). This approach is also linked to how technologies serve as symbolic activity through which we construct identity, as argued in 'uses of knowledge' section 2.4 (p.42), previous chapter.

Thus, technology as *symbolism*, in Misa's fifth approach, is not only symbol-making and culture changing but also, in the infrastructure of daily life, it is society constituting (Misa et al., 2004). Taking it one step further and emphasising issues of power, Hecht and Allen (2001) assert that artefacts, knowledge, and systems that are commonly recognised as 'technological' are precisely perceived as such because they have served as instruments of 'expert power'.

They further note that popular uses of the word technology today increasingly refer only to computer-related artefacts and networks; such conceptions, they argue, reveal that what counts as technology changes over the time, precisely because that designation continues to be an indicator of legitimacy and power dynamics. Bringing it to a more individual scale, and specifically referring to experiential learning, Papert (in Blikstein, 2013) reminds us that the real power of any technology is not in the technique itself or in the allure it generates, but in the new ways of personal expression that it enables, the new forms of human interaction it facilitates, and the powerful ideas that it makes accessible.

These five approaches to defining technologies mostly refer to either large technological systems or general technologies. Nonetheless, they spark questions about the relationship between technologies, knowledge, and power in DIY enquiry. Framing and addressing these questions, however, requires a new conceptual and analytical mix, one which I explore next.

3.2 Perspectives on technology as tools for analysis

'Technology' is conceptualised from a wide range of (sometimes siloed) perspectives. These include HCI, PoT, STS, Social Construction of Technology (SCOT), Social Shaping of Technology (SShT), and HoT and converge on aspirations for more open, aware, and just societies. Each also provide useful concepts and frameworks for the analysis of DIY practice, which I present in Figure 3.1 at the end of the chapter.

The strands of HCI research looking at DIY and maker culture, for example, focus on the creativity and skills attained/developed by makers, the creation of tools and spaces for making and learning, and the expertise and empowerment of the maker culture (Jennett et al., 2016; Kuznetsov & Paulos, 2010; Tanenbaum et al., 2013; Toombs et al., 2015). Some of these are discussed in the following sections.

From the PoT, or critical constructivism perspective, Feenberg's (1999) influential critical theory of technology has guided studies taking critical stances on social engagement to consider technology as a terrain of contestation and intervention. For example, Haklay (2013b) builds his hacking hierarchy on Feenberg's 'instrumentalisation theory', which holds that technology must be analysed at two levels, that of seeking affordances and that of designing and implementing. Haklay's hierarchy, which I describe in the next chapter, is

helpful in conceptualising and guiding a movement towards achieving the democratisation potential of technological practice in citizen science.

From an STS perspective Winner (1986a) suggests that artefacts have inherent politics, that is, arrangements of power and authority. While that power can be exercised in the way artefacts are designed, he argues that it is in fact the societal structures in which our practices are embedded that dictate the politics of artefacts – a point to which I return in the theoretical model (Chapter 5). Also, from within STS, Jassanof (2007) advocates for humility: acknowledging the limits of scientific knowledge and adopting methods that "compel us to reflect on the sources of ambiguity, indeterminacy, and complexity" (p.33). This is linked to more recent endeavours committed to STS scholarship as political theory. Linking back to the 'tensions in expert knowledge' (section 2.5.1, p.42), these studies have focused on how 'lay expertise' can become established and institutionalised as part of the process of technological decision-making "without the need for protest driven by initial exclusion" (Thorpe, 2008, p. 77) (e.g. Delgado et al., 2010; Lave et al., 2010; Stirling, 2007).

As argued in the previous chapter, constructivist and structuralist ontologies and epistemologies serve as useful foundations for the understanding of DIY enquiry and practice. The two approaches in *Social Studies of Technology* (SST), SCOT (Pinch & Bijker, 2011) and SShT (Bijker & Law, 1992) are anchored to these perspectives. They emerge as criticisms of the linear model of innovation (moving from discovery, to development, to market) and technological determinism. Stemming from sociology, these SST approaches focus on how the social and technological context of development shapes choices in innovation.

Central to SShT is the mutual shaping between technology and society. Akin to Winner's perspective and the structuralist approach, SShT theorists hold that the ways a technology is used cannot be understood without examining how that technology is embedded in its social context. Based on this, Bijker and Law outline (1992) five considerations for the analysis of technological development, which can be applied to the analysis of DIY enquiry because of its parallel to Grounded Theory, as I discuss in the methodological theory (Chapter 6). As seen in Table 3.1, a focus on *interactions* acknowledges heterogeneity; *conditions* enables pinpointing the source(s) of development of technologies (if possible to determine), *strategies* acknowledges roles of stakeholders, *settlement* acknowledges negotiations and mediations between actors, and *consequences* helps to identify opportunities and barriers created.

Table 3.1: Considerations for the analysis of technological development applied to DIY (Based on Bijker & Law, 1992 and Klein & Kleinman, 2002).

Interactions	Technological change is contingent on heterogeneous, emergent, and networked social interactions e.g. potentiality of multimodal ways of doing in DIY is acknowledged
Conditions	Technologies are born out of conditions of conflict, difference, and resistance (as responses to implications of technological development and leveraging from different social groups) e.g. helps to pinpoint what triggers development of technologies
Strategies	Those involved in dispute/disagreement/resistance deploy strategies (combined legal, organisational, political, economic, scientific, and technical) to halt or impose an alternative version of technological and social relations e.g. the acquisition of new technical skills to gain strategic advantage (manipulating the system by learning to code)
Settlements	Technologies are shaped by compromise or negotiation of settlements (not always egalitarian) e.g. arrangements sought through civic action such as establishment of Creative Commons
Consequences	Several factors influence the strategies and the consequences of the strategies deployed (the opportunities and barriers created are also unequally distributed/redistributed) e.g. new law defining what constitutes as acceptable evidence passed; citizen data recognised

The SShT perspective received heavy criticism for ignoring structure and for its pluralistic approach and thus, was complemented by Klein and Kleinman's (2002) considerations for *structural factors*. These assess the relative *capacity* of actors in shaping artefact construction and are factors affecting

- *relevant social groups around an artefact* (e.g. what factors prevent some groups from participating; what promotes the formation of certain social groups; what factors affect a group's ability to pursue certain interests; and in terms of issues of power, what gives certain actors advantages over others?);
- *systems of meaning and interpretation of an artefact* (e.g. some codified systems of meaning such as rules, regulations, standards, might have more limiting power but being so deeply ingrained they might not be so easily recognised);
- '*closure*' – collapse of design or meaning and interpretation of artefacts (e.g. national law, regional policy, and deadlines may weigh more on decision-making than the rhetoric of designers promoting an artefact); and

- *impact* – considerations for concentration and dispersion of groups (e.g. those who are unorganised, fragmented, or dispersed are likely to have less influence than centralised or contracted groups in negotiating at higher levels of authority – there is power in numbers!)

These considerations can be further complemented by an analysis of social shaping at the macro-, meso-, and micro-levels offered by Misa (1992). The 'meso-level' analysis links the micro-level analysis and the macro-level analysis. The micro-level concerns the local, everyday world; the macro-level concerns structural factors. The 'meso-level' is of interest because it represents the mediation by institutions, institutional arrangements, and networks, which in turn define the process of technological innovation – a mediation process that some DIY initiatives aim to influence, as I explain below. This HoT perspective is relevant for the study of DIY because it acknowledges the everyday concerns, habits, and motivations of the men and women who have historically pursued new ideas and lines of enquiry. It also considers how these were shaped and nurtured by the world in which they lived. Historians argue that people and practices have left an indelible mark on science and technology as we know it today (Jardine, 2013). In other words, "every technology must be understood in terms of the particularities of its context of origin" (Staudenmaier, 2001, p. x). In considering the micro-, meso-, and macro-levels of analysis, we can see that while tinkerers, investigators, and inventors, each have a "distinctive cognitive style, a blend of theoretical expertise and experience-based practical judgement" (ibid), the outcome of technical design is also affected by these people's motives, world views, and the resources of the people involved. Technologies are also shaped by the ambient social order and its political and economic character (Staudenmaier, 2001; Winner, 1986a). These conceptions begin to form the basis of model of factors and considerations for the study of technical DIY presented at the end of the chapter in Figure 3.1.

Many of the fields described above focus on large technological systems but I have tried to illustrate how their considerations can guide the study of DIY enquiry and DIY technologies. To ground this further, let me first expand on what is meant by 'DIY technologies'. DIY practice is characterised by 'doing', 'making', 'intervening', and 'taking initiative' (Ratto & Boler, 2014b). DIY enquiry is about figuring things out by oneself, experimenting, and questioning the state of things to find potential solutions to local concerns or exploring interests. Following the approach of 'technology as knowledge' above and based on Certomà & Pimbert's (2013) definition of knowledge, I define DIY technologies as the tools and

technical know-how (development, application, interpretation, etc.) employed and acquired through the practice of self-learning and self-reliance. As symbolism, DIY technologies also represent a stance on DIY. I develop this notion further in Chapter 5, based on 'argument-by-DIY'. Hence, shedding light on the *interactions*, *conditions*, *strategies*, *consequences* in the making of DIY tools, their use (practical, political, hedonic, etc.), factors shaping its development, and consequences of practice, aids in the understanding of what practices of DIY enquiry do to people and what people do with these practices. From the SShT perspective these include resource distributions, capacities, and incapacities and these in turn define specific constraints and opportunities for actors (Klein & Kleinman, 2002; Kleinman, 1998).

In studying 'DIY citizenship' and 'critical making', Ratto (2014) considers that a critical analysis of technologies that does not connect its results back to the examined technologies has limited usefulness. Ratto (2014) and Veak (2000) argue that while classical theoretical frameworks remain valuable analytical pillars (e.g. the various works of Mumford, Ellul, and Heidegger), they address either technological systems or Technology (capital T, opposite to pluralism in technology) in ways that are far-removed from our everyday world; that is, they do not reflect the practices of use and design of (DIY) technologies and the harsh realities of inequality. Hence, on a sobering note, Dunbar-Hester (2014) states that to bridge this gap (whether one holds a traditionalist view or is a propagator of DIY technology) we need to openly recognise our partialities (i.e. becoming more accountable) and our limited power/reach (i.e. avoiding romanticised notions of participation, agency, and democratisation). Hence, I now move onto complementing these analysis frameworks with more focused conceptualisations of DIY technologies.

3.3 Conceptualising DIY technologies

In this thesis I take the stance of 'technology as knowledge'; that enquiry, discovery, and innovation have long been aided by artefacts; that ingenuity intertwines enquiry with technical development in pursuit of understanding and changing circumstances and the surrounding environment. Some argue that our very survival hinged on our ability to repair and repurpose tools and materials (Kuznetsov & Paulos, 2010). This interplay between tools, practice, and knowledge is fraught with tensions and it is through these tensions that we can conceptualise and situate DIY technologies. I briefly present some defining conceptions on technical citizen-led initiatives and conceptualisations about enquiry at the individual and

group levels and the role of technologies. I also link back to and illustrate some of the main points highlighted in section 2.5.1 (p.45) on 'tensions in expert knowledge', namely, the manifestation of 'institutionalisation and normalisation of expertise' in technical DIY and the problematic construction of publics and narrow framing of expertise.

3.3.1 Notions on citizen-led initiatives

In the literature DIY is characterised by its emphasis on 'doing' and the active roles of 'makers', 'hackers', 'maktivists', and 'tinkerers'. Acts of making and investigating, iterative imagining, creating, testing, failing, and learning shape relationships to DIY technologies and form cultural, technical, and material identities. The 'appropriation', 'modification', and 'transformation' of meanings, interactions, and concerns in citizen-led initiatives are described as timely (e.g. Ushahidi (Gigler & Bailur, 2014)), accessible (e.g. inexpensive equipment and understandable content in DIYbio (Delgado, 2013)), and networked (e.g. operation of community-led sensing networks such as 'Air Quality Egg' (Kumar et al., 2015)).

However, throughout this literature there seems to be an underlying emphasis on 'intervention' (and the role of the interventionist). It evokes a sense of urgency, but the term is more frequently associated with state or military interference (OED) and hence, DIY is becomes linked with belligerent action. But are all DIY practices acts of resistance? And are all DIY technologies political by default? Literature on hedonic DIY highlights pleasure, aesthetics, and self-expression, and is mostly linked to crafting, but there is also an underling rhetoric of intervention: DIY (as in designing-it-yourself) is political because it is about giving meaning, making purposeful choices, conveying values – and the ownership that comes with these (Irani, 2008; Jacoby, 2013). Exploring the difference between 'design' and 'making' in depth is outside the scope of this research as the focus here is on the cognitive and technical aspects of engagement in DIY and grassroots initiatives (Figure 1.1, p.25). However, it is worth noting that in the last decade 'making' has acquired a new cultural meaning due to the 'maker movement' and Tim O'Reilly (in particular through MAKE magazine) and Dale Dougherty with the maker manifesto. In their narratives as well as those of maker educators e.g. Gerstein (2016) (see section 2.2.3 Spaces for experiential learning, p.39) 'making' and 'design' interchangeably.

To understand the potential of DIY enquiry, what it does to people and what people do with it, we need to on the one hand, bring together the various notions and angles on it – in particular, in the context of the digital age: the focus on creativity and learning, the formation of culture and identity, the collaborations and networked interactions sought and realised by grassroots efforts, and the exclusion and inequalities linked the larger socio-economic climate and forces of capitalism. On the other, we also need an understanding of the preconditions for engagement in DIY enquiry and the link between enquiry and DIY technologies. Conceptions from Development Studies and Information Systems (IS) can guide the understanding of technical engagement with DIY at the individual and group levels.

3.3.2 Enquiry and DIY technologies

What is needed to engage in the practice of DIY enquiry? Smith and Fressoli (2016) note that the availability, promptness, and connectedness of open hardware does not nullify the need for technical skills in technology development. They argue that in fact, there is an underlying 'craft' (hands-on competency) element to even the 'easiest' of digitally enabled tools. Arguing for 'material competency', Barba (2015) contends that design literacy is fundamental because 'making' performs the same rhetorical and educational functions as other forms of knowledge production. However, as noted in section 2.6 (p.48), competency encompasses not only technical skills but also the more subtle interpersonal and social skills in community participation. In addition, as Smith and Fressoli (2016) argue, if open hardware is to be genuinely inclusive, then its practices must actively promote both 'hard' and 'soft' skills. That is, in order to participate, notionally accessible tools need to become actually available, and people need to feel confident using them. The rise in spaces for experiential learning and 'maker education' (section 2.2.3 p.39) attests to a move in this direction (although it is not without issues, as I discuss in section 3.4). But what makes tools 'notionally accessible' and how is this confidence-in-use developed? Several concepts from the Information Systems literature including 'cognitive absorption' and 'epistemic curiosity' may serve to conceptualise these relationships to technologies and engagement in DIY enquiry.

Agarwal and Karahanna (2000) define 'cognitive absorption' (CA) as the state of deep involvement or holistic experience with technologies (e.g. ICTs, software, etc.). CA has five dimensions: 'temporal dissociation' (the inability to register the passage of time while engaged in interaction; a sensation of loss of sense of time), 'focused immersion' (the experience of

total engagement and ability to 'ignore' all other demands), 'heightened enjoyment' (where pleasurable aspects of the interaction are experienced and heightened), 'control' (representing the user's perception of being in charge of the interaction), and 'curiosity' (the extent to which the experience arouses an individual's sensory and cognitive curiosity). Furthermore, Malone (1981, in Agarwal & Karahanna, 2000) notes that playfulness, imagination, and personal innovativeness determine CA.

These insights are used to design digital devices and gaming software, and although cognitive absorption and DIY have not been linked in the literature, they can help to understand the conditions for 'notionally accessible' tools and confidence-in-use: the five dimensions and determinants of CA fit the description of experiences of DIYers being immerse or 'in the flow' when engaged in developing or using DIY tools (e.g. Heimbuch, 2012; Levine & Heimerl, 2008; Regalado, 2015). DIYers also experience a drive to know more – knowing how something works or 'getting something to work'. This links to 'epistemic curiosity' (EC), introduced by Berlyne (1954) to describe the individual desire to gain new knowledge and doing it by closing information/knowledge gaps and tackling intellectual problems. Litman and Jimerson (2004), disambiguated EC into two manifestations: as a predisposition to become curious (termed 'interest type' EC) and tendency to feel deprivation ('informational deprivation type' EC), terms which shed light on individual's purpose of engagement in enquiry. In their study of online communities of practice Litman and Jimerson (2004) found that there were members actively seeking new knowledge to satisfy a need or want for information (these 'lurk' before contributing with questions/answers); others display an inherent lasting desire to gain new information (participate actively); and others enjoy the pleasure of discovering new ideas 'in passing'. They also found that community members with higher 'tenure' in the community tend to contribute because they are driven by altruistic motives or concerns for the welfare of the community. Specifically, Litman and Jimerson found that some tenured community experts dedicate themselves replying to complex questions posted by members but first reflect on the problem to provide an accurate and satisfying answer (i.e. they first satisfy their information deprivation). These findings highlight that making 'notionally accessible' tools cannot take for granted the committed peers who have/make the time and that these peers in themselves have gained the social and technical skills needed to engage with confidence.

Other considerations for making tools 'notionally accessible' and gaining confidence to use them are the beliefs and attitude we have towards them. Webster and Martocchio (1993)

found that if there is a sense of being in charge and exercising control, then there is reduction in perceived difficulty in performing technical tasks – in fact, this attitude invokes excitement about available possibilities. They termed this 'amplified curiosity' and posited that this excitement serves to reduce cognitive burden in engagement. They also found that in addition to beliefs and attitude, motivational factors play at least an equally important role and may actually be the primary driver of new technology use; one's desire to exercise control over technologies and their functionality strongly determine intention to use new technological artefacts. This is of relevance to understanding technical DIY because it also sheds light on how some overcome barriers to engagement.

CA and EC shed light on reasons for engagement, conceptualising cognitive interactions with technologies at the personal level, and factors affecting engagement with technologies at different stages. I now move onto the institutional tensions in engagement with DIY enquiry.

3.3.3 Tensions from the institutionalisation of expertise

One of the main critiques by 'resistance groups' is that the current supply chain for science hardware limits access and impedes creativity and customisation for other groups (http://openhardware.science)., These groups have, in response, developed a wide range of individual and organisational strategies to systematically address these issues, from going off the grid to creating a Manifesto and networked community to support and materialise the values they share on open science hardware (ibid).

In exploring the tensions in the 'two-sided nature of technology', Feenberg (2003) distinguishes between the *strategies* of those groups who have an institutional base from which to exercise power and the *tactics* of those who are subject to that power but who, lacking a base that provides continuity, legitimacy, and ability to act, must manoeuvre and improvise micropolitical resistances. He conceptualises the latter as 'democratic resistances' (or alliances of disempowered groups). From this perspective, Feenberg (2003) argues that technological systems impose a type of 'technical management' on people in which some manage and others are managed. These two positions correspond to De Certeau's strategic and tactical standpoints. Feenberg (2003) explains:

> [T]he strategic standpoint privileges consideration of control and efficiency and looks at the world in terms of affordances. […] The tactical standpoint […] is the everyday lifeworld of a modern society in which devices form a nearly total environment. In this environment individuals identify and pursue meanings. Power is only tangentially at stake in most interactions, and when it imposes itself, resistance is temporary and limited in scope by the position of the individuals in the system. Yet, insofar as masses of individuals are enrolled into technical systems, resistances will inevitably arise and can weigh on the future design and configuration of the systems and their products (p.228).

Within DIY communities, however, this binary conception is deepened by another tension: a simultaneous critique and dependence on technical infrastructure. Tanenbaum et al. (2013) argue that the tension lies in that this infrastructure (e.g. trade infrastructure, standardisation mechanisms, etc.), which supports exchange and economies-of-scale, is the same infrastructure that provides these communities with access to the raw materials and literacies that drive these practices (e.g. specialised tools and techniques). In this case, 'democratic resistance', Tanenbaum et al. (2013) argue, creates an "area of simultaneous participation, critique, and resistance" (p.2609), which in turn leads a 'paradox of standardisation' as groups and organisations grow and new voices are empowered. The paradox lies in that while DIY communities deeply value independence, inclusion, and agency, as they grow, extend their efforts, involve more voices, etc., the structures of organisation, the technologies, and the infrastructures that supports them become more layered and this leads to rigidity and exclusion. That, is, new sources of authority are established and reified by the community and these potentially extend or reproduce existing systems of power (Dunbar-Hester, 2014; Powell, 2016; Tanenbaum et al., 2013); their tactical standpoint runs the risk of taking on the very same aspects they critique of a strategic standpoint.

Is it inevitable then that as these 'resistance groups' grow they will have to battle not only the unequal power relations perpetuated by capitalism but their own changing internal logic and management, which is equally at risk of reproducing inequalities? Feenberg (2003) reminds us that the alternatives that we propose are not only conditioned by the failures of existing technologies but also by the possibilities they suggest. We are tainted by failure; but can the diversity of DIY refract immense possibilities? How are/can these be realised?

3.3.4 Power in technical DIY

Power in DIY can be conceptualised as material, symbolic, and as acting internal or external to DIY practice. The design of 'technologies of resistance', Milberry (2014) notes, is an example of how values (e.g. of social justice movements) are designed into technologies. These technologies represent, support, and build on 'politics of emancipation': it is not only a form of political participation but a process of self-definition and self-reflexivity for transformative praxis. Similarly, the goal of 'critical making' is one of using material forms of engagement with technologies to supplement and extend critical reflection, including the creation of evocative artefacts that not only provoke discussion, explorations, and critique but also embody values and ideals (McPhail et al., 2014; Ratto, 2011). This is akin to Allen and Hecht's (2001) focus on the strategic practice of designing or using technology to enact political goals, defined earlier as 'technopolitics'. Weimar and Hecht (in Hecht & Allen, 2001) questioned the relationship between technology and social change as political practice. They note that "the ways in which technologies perform expert power must be understood with reference to symbolic beliefs about how technological change operates in the world" (p.14). They state that it is actually *beliefs* about the social and political dimensions of technological change that shape real social and political change. Although they were referring to 'expert power' from the strategic standpoint, this also applies to grassroots technical DIY. Let me illustrate this.

In their study of environmental organisations, Jalbert and Kinchy (2016) found that the demands for 'more' and 'better' data in environmental monitoring (driven by a belief in 'big data') led to an increase in the use of environmental sensors. This has led to a strong focus on the technical dimension of data collection methods and technologies (e.g. Cohn (2008) and Silvertown (2009)), leaving the implications of technologies on public participation and capacity for empowerment unacknowledged. Jalbert and Kinchy argue that in fact, when devices such as automated data loggers are introduced, volunteers become less important as primary sources of knowledge about their environments (Jalbert & Kinchy, 2016, p. 393), thus strengthening the technopolitics of organisations who coincidentally become the gatekeepers of the data (produced by replaceable volunteers) and use of (reliable and objective) technology. That is, the adoption of data loggers implies an emphasis on quantitative data, rather than the knowledge and voices of informed, concerned citizens.

Jalbert and Kinchy (2016) firmly argue that automated technologies, however effective they may be in gathering data on environmental quality, are not well designed to support broad public participation in environmental science and politics: they might provoke explorations but do not invite discussion nor critique. The increased use of automated devices tends to reinforce hierarchies of 'expert power' and constrains the agendas of 'non-professionals' as they only embody the values and ideals of organisations. This is akin to Albert Borgmann's 'device paradigm', the generalised trend in which technology promises to enrich and disburden people's lives, but instead takes away a fuller engagement with reality (Haklay, 2015). Jalbert and Kinchy (2016) argue that if an organisation's primary objective is to maximise the number of data points collected, then technologies such as data loggers may prove superior to volunteers. However, monitoring tools can change the nature of 'public'. Technologies, they argue, do more than their intended technical tasks of recording; they also affect practices and relationships, altering the means by which concerned citizens can participate in public debates.

3.4 Factors affecting development and use of technologies

The Internet is one of the most distinctive features of the digital age. Discussing the interplay between cultural, political and economic forces in shaping the digital world is outside the scope of this thesis but it is important to acknowledge that trends in these mould the concomitant development of online infrastructure and practices – from the reproduction of economic inequalities to the perpetuation of power relations through race and gender divides. These in turn has influence the development of grassroots and DIY culture at the social, organisational, and individual levels (Allen & Hecht, 2001; Feenberg, 2003; Ratto, 2011).

McChesney (2013) examines these trends from the view of the celebrationists and that of the sceptics. The celebrationists, he argues, point out the good that the Internet and the digital age have brought about in (Western) societies; it has, for example, contributed to an abundance of increasingly affordable tools that range from online distributed innovation tools (e.g. smartphone software, blogs, wikis, peer to peer software, etc.) and processes (e.g. social mapping, the collection of volunteered geographic information, geo-referenced social networking, etc.) to devices (e.g. personal computers, mobiles phones, Wi-Fi modules, micro-controllers, cameras, lab equipment, etc.). Some argue that the ad hoc design of freely

accessible crowdsourcing platforms are being issued by grassroots, research, and policy-making institutions and that these are enabling technology-mediated forms of public participation in science and policy production (Certomà et al., 2015). Others note that these networked practices are challenging modern configurations of truth and authority and bringing on a new understanding of what it means to know and how it means to know multimodally (Castells, 2011; Jenson et al., 2014). It is celebrated that DIY projects can now be readily shared with large audiences who can collaboratively critique, brainstorm and troubleshoot their work. Kuznetsov and Paulos (2010) contend that it is this accessibility and decentralisation that has enabled large communities to form around the transfer of DIY information (e.g. GitHub, Instructables, etc.), attracting individuals who are curious, passionate and/or heavily involved in DIY work. In sum, for grassroots movements the Internet has facilitated social interactions with different ways to learn, act, respond, question, and share tools, techniques, and ideologies (Bioneers, 2015; Shkabatur, 2014). Fringe groups are gaining a foothold in mainstream media and academia alike (Paulos, 2012).

The sceptics caution against the claims of 'cognitive surplus' (Shirky, 2010) and 'collective intelligence' (Jenkins, 2006) because more information does not aggregate to a great scientific achievement or a more informed public (Collins, 2014b; Lanier, 2010; Mohammed, 2012). Others argue that the Internet compromises quality and anonymity promotes social harms (Keen, 2007; Levmore & Nussbaum, 2012). Others further critique that digital devices are creating obsession and loneliness and people are becoming less inquisitive because of filter bubbles from web browser algorithms tailored to 'suit you' (Pariser, 2011; Turkle, 2011). Others are sceptical of the claims to egalitarianism and democratisation because most celebrationists ignore issues of class, gender, and power relations (Eubanks, 2012; Morozov, 2012). And others further note that digital devices affect the way we do things and how we think – or not; a recent study shows that the use of satnavs 'switch off' the parts of the prefrontal cortex that help us plan how to get to our destinations (Javadi et al., 2017).

Together these arguments make up the intellectual puzzles pieces that reveal how we are defining the landscape of our time in the digital age: our concerns, interests, aspirations and contradictions. But they also represent and point to a more fundamental and underlying feature of humanity: enquiry, which is sometimes alluded to but often taken for granted (perhaps because we move too quickly from enquiry to claim). These are the ways we seek knowledge, figure things out, experiment, and question the state of things, make arguments and pursue potential solutions – using, critiquing, repurposing, transforming, and leveraging

artefacts, online tools and processes, and their symbolisms. And while Dunbar-Hester (2014) reminds us that DIY tools and techniques do not in themselves find solutions, as argued in the previous chapter, I argue that they do have the potential to serve as media with which people ask questions and make issues more visible. DIY technologies are fraught with tensions and are embedded in complex socio-economic and political contexts, but they still represent potential powerful means of making sense of the world and facilitating citizen-led enquiry. Moving from general challenges in technology, I now move on to explore literature on the specific challenges in and for technical DIY practice.

3.5 Challenges and opportunities DIY practices and technologies

It can be argued that DIY practice faces conceptual, practical, and systemic challenges. Conceptual challenges include fragmentation in the definition of DIY practice and 'broken promises' of democracy, practical issues relate to access, and systemic issues to socio-economic inequalities. This list is by no means exhaustive nor are these issues disparate; much remains unknown until after the fact in DIY and some of these practices are still emerging. However, existing literature sheds light on some of these issues and helps to conceptualise barriers and opportunities in DIY. I briefly discuss these challenges next.

As noted in the introduction, DIY is an identifiable collective behaviour of self-reliance (Wehr, 2012). This is not to imply homogeneity in DIY practice; in fact DIY has seen an influx of new members subscribing to and therefore widening the definition of the types of activities that fall under its banner (Barba, 2015). Identified as hacking, (critical) making, tinkering, and crafting, its aims and agendas range from (a combination of) entrepreneurialism and democratic participation to subversive critique and artistic self-expression. While this diversity is a strength in providing nuanced alternatives to local problems, Barba (2015) argues that with conflicting aims, interests, and values, it is no longer clear what it means to do DIY and therefore the term is in imminent danger of losing its meaning. An additional challenge linked to this is that this perceived fragmentation affects the legitimacy of DIY practice (Beebeejaun, 2016). I discuss this further in Chapter 4. This also leads to doubts about whether these new methods of control will result in long-term reconfiguration of the social and cultural practices of society or whether they are simply new ways of reproducing existing sociocultural relations (Barba, 2015, p. 639). At the same time,

some notions of DIY are receiving more attention (or have more funding for PR campaigns) than others – notions which promote a powerful promise: 'democratisation of technology'. Promoters include popular media (e.g. O'Riley and Popular Mechanics) and institutional programmes (e.g. ICT4D) supported by academics (e.g. Atkinson (2006), Meyer (2013), von Hippel (2005)). Yet, the hype of this promise has left ongoing issues of access unattended. Haklay (2013b) lists three. First, access: in order to participate people need access – and many are already excluded at this point, technically and digitally. Second, mastery: to take ownership people need to master techniques that, as noted above, take time to learn. Third, ownership: beyond who can use these technologies, "[t]he control over the information is kept, by and large, by major corporations and the participant's labour is enrolled in the service of these corporations, leaving the issue of payback for this effort a moot point" (Haklay, 2013b, p. 65). I explore these technical issues further in section 4.3.1 'limits to engagement'.

Buechley (2014) argues that with tools still being too expensive for the lower income population and with funding going to the 'usual suspects' (e.g. DARPA grant for MAKE Magazine education initiative (makezine.com)), the 'maker movement' (or this MAKE-branded version of it) is not currently living up to its promise of 'democratisation' and 'every child a maker'. It is not offering new opportunities for marginalised groups. In her Eyeo 2014 talk, Buechley (2014) poignantly criticises the incessant perpetuation of initiatives and same old structures disguised as a new thing "where we tell young women and young brown and black kids that they should aspire to be like rich white guys". This comes in response to disparity trends including those of a MAKE magazine market analysis study done in 2012. The analysis of their subscribers and visitors to 'Maker Faires' revealed astonishing demographics: 81% male; median household income of $106,000; 73% own home; most are married and 40% have children; 97% attended or graduated from college; 80% have post graduate education; and over 40% hold post-graduate degrees. MAKE magazine itself has similar trends in their editorial staff and the people they represent on their covers: 85% males and 0% minorities. Buechley (2014) argues that this is not limited to MAKE, it is a systemic problem of disproportionate participation; it applies to other groups who identify with an ethos of 'openness' and 'possible to everyone'. Dunbar-Hester (2013) stresses that the DIY approach in itself does not necessarily challenge or address systemic and structural limitations that contribute to the ongoing marginalisation of people. In fact she states that "DIY itself has traditionally not been for just 'anyone', and an especially the technical strand of DIY may have been particularly saddled with this legacy". She advises:

> [A]ctivists concerned with not losing sight of the 'social mediations of technical production' may wish to attend more closely to where technical cultures come from – and in particular the ways in which technical DIY may import some values they do not share – as this could prove beneficial in building a desirable and egalitarian politics of technology.

Storni (2015) notes the challenge for the type of DIY tools hatched and promoted by academics and professionals when they do not practice a critical awareness of their political role as designers: it is not only about developing more functional, inexpensive, appropriable, hackable, usable technologies – the opportunity lies in that they are in a position to also construct legal, aesthetic, and socioeconomically viable infrastructure that supports DIY in general. This is the same call mentioned in Chapter 1 made by Rydin (2007) a decade ago. Critique and awareness is increasing but we must ask if these are scaffolding up to build mechanisms at the institutional level that can enable the handling of multiple knowledges and approaches to technologies from below?

Some DIY communities are working to develop long-term sustainability in a distributed open source science effort by building alliances with other communities of 'lay expertise'. Many of these groups represent an ongoing experiment in adapting and replicating practices that have similar foundational values (e.g. from open source software communities) (Hemphill & Leskowitz, 2013; Kera, 2012). Breen et al. (2015) argue that the greatest strength of these communities lies in their diverse abilities – to innovate beyond the limitations of traditional practices, to find alternative ways of questioning practice, to share and gain feedback, and to offer alternatives to current institutional approaches to problem solving.

3.6 Situating DIY technologies

From the stance of technology as knowledge I link back to Certomà and Pimbert's (2013) definition of knowledge (section 2.1, p.34), which acknowledges the interplay between artefacts and their symbolism, the techniques acquired and developed through interactions embedded in and creating culture, and the consequences of development and use of technologies – all of which occur within the larger socio-economic climate and forces of capitalism.

In seeking guidance from the literature to understand what people do with DIY tools/techniques and what DIY tools/techniques do to them, I draw from a range of

disciplines and conceptual frameworks, which complement each other, as represented in Figure 3.1. These concepts help us to appreciate the broad spectrum of factors determining the role of technologies in DIY: from sources of wonderment, inspiration, and learning, to a medium for exploration, production and control, formation of identity and critique, and collaborative and networked interactions, to a form of exclusion, privilege, and perpetuation of power relations.

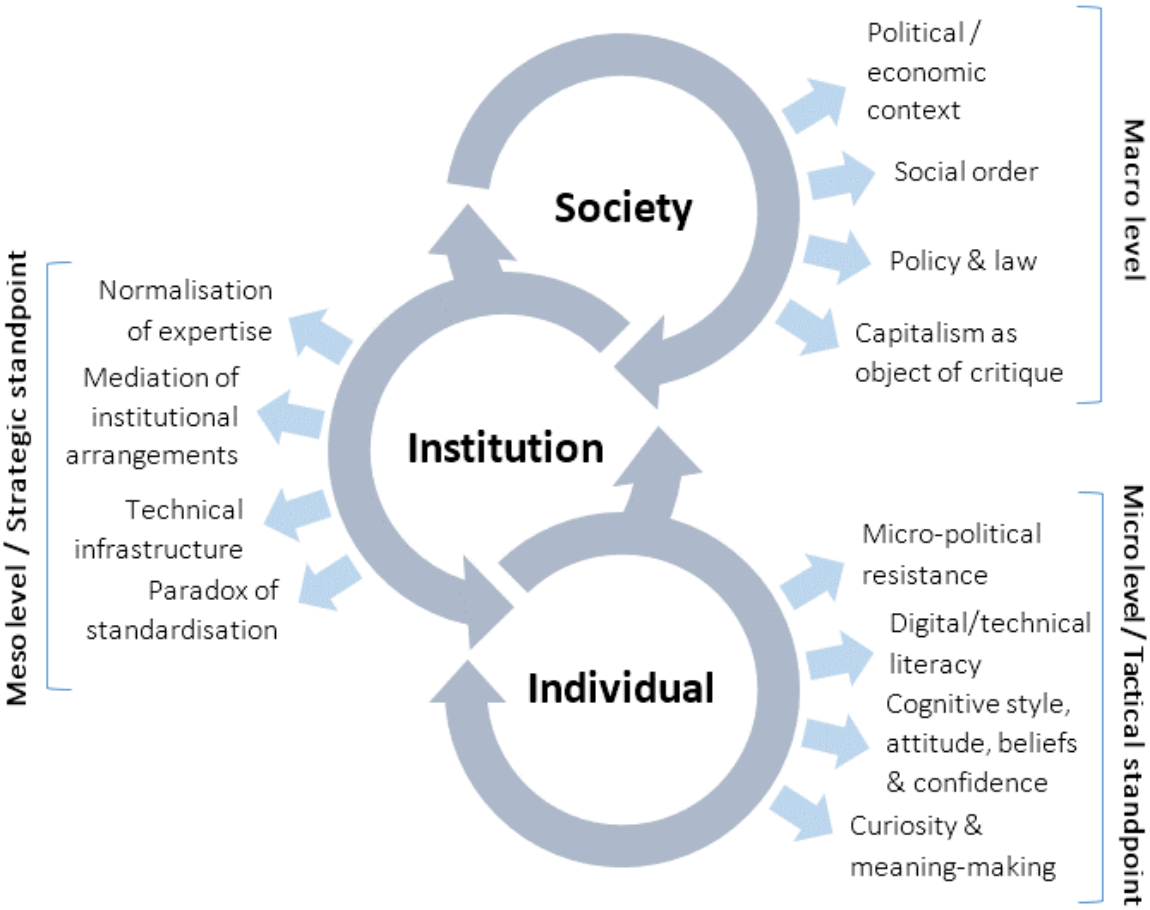


Figure 3.1: Modelling the literature on social shaping of technologies: levels of analysis, factors and considerations for enquiry in technical DIY. Represented by the backwards arrows, all three levels shapes each other.

Figure 3.1 situates technical DIY at three interrelated levels: a) the societal level with considerations for macro-level analysis (e.g. what is the larger context that underpins DIY practice and what is it in response to?); b) the institutional level with considerations for meso-level analysis on the symbolism of expertise (what are its effects on mediation of institutional arrangements, and infrastructure design and use?) and leverage of power from a strategic standpoint; and c) individual level with micro-level analysis taking into account factors

influencing engagement with technologies (from competency to attitude) and the concomitant conditions shaping tactical standpoints, as 'everyday practice'.

Smith and et al. (2017) firmly state that it is only through a mix of craft, politics, and the support of social movements, that DIY/grassroots technologies will fully realise their potential of being truly accessible and to continue being a source of critique and pressure for traditional approaches. As Haklay (2013b) reminds us, to fully realise this potential, the mechanisms of exclusion that these different technologies and techniques introduce need to be acknowledged and addressed (Haklay, 2013). I discuss this in the next chapter.

4. Situating public engagement

This chapter presents some of the different theoretical approaches and arguments on public engagement in science and technology and situates them in terms of standpoint on practice. I begin with a definition and theoretical categorisation of public engagement including citizen science and grassroots science. I then present some of the main challenges and opportunities in public engagement practice and describe a model that helps to situate DIY enquiry within public engagement.

4.1 Defining engagement and participation

'Engagement' as a concept evokes ideas of enrolment, commitment, interest, and even purpose (e.g. Davies et al, 2012; Foth et al., 2011; Marris & Rose, 2010; Schafer, 2008). Its depiction in both social and science literature ranges from 'carefully planned and purposeful pursuit' to 'ad-hoc venturous undertaking'. The study of motivation for 'engagement' in science and technology has its roots in various fields – with disparate intents and concerns. However, what it is not often made explicit is engagement of whom, in what, and how? By addressing these questions, a new literature emerges – equally questioning approaches 'from below' and 'from above' on issues of inclusion, barriers, and opportunities.

'Participation' is a broad term associated with public engagement, often embodying a desirable practice of social transformation that values 'inclusion' and 'democracy' (Bäckstrand, 2003; Cunningham-Burley, 2006; Fals-Borda & Mora-Osejo, 2003; Felt & Fochler, 2008). Critiques of the concept base their arguments on instances of its misuse including 'participation' as rhetoric that promises empowerment and as more talk than substance subject to manipulation (Cooke & Kothari, 2001; Hickey & Mohan, 2004). Its practice is also criticised as 'forced entry' imposed as policy and adopted by governments rather than a form of democratic involvement (Miessen, 2010). Others critique the general conception of 'participation' as an all-inclusive tool for legitimisation that has achieved the status of buzzword, and has been reduced to a series of methodological packages and techniques (to be distributed and measured), and where it loses its philosophical and ideological meaning (Irwin, 2014; Leal, 2007; Miessen, 2010; Jack Stilgoe, Lock, & Wilsdon, 2014). Within social studies of science and technology, and in particular literature critically

addressing public engagement, 'participation' or participatory methods involving technologies the focus on the 'potential' of its methods and approaches (e.g Haklay, 2013a; Irwin, 1995; Lave, 2012; Smith, 2012; Wynne, 2007, 2009). Yet, participation and engagement remain desirable but nebulous concepts and hence, their significance in practice and for policy also remain elusive. This is especially the case when conceptualising citizen-led initiatives, and in particular those seeking social transformation through social mobilisation, which I turn to in section 4.2.1.

4.2 Conceptual perspectives on engagement

The subject of public engagement is wide-ranging with perspectives under the banner of *Public understanding of Science* (with a journal dedicated to it), *Public acceptance of Science* (Frewer et al., 2004; Gauchat, 2010; Kurian & Wright, 2010; Martin, 1981; Sasaki & Suzuki, 1991), *Deliberation of science and technology* (Bloomfield et al., 2001; Delli Carpini et al., 2004; Hagendijk & Irwin, 2006; Macnaghten et al., 2005; Powell & Colin, 2008), *Science education* and *Scientific and technical literacy* (Bonney, Cooper, et al., 2009; Good & Shymansky, 2001; Lin, Hong, & Huang, 2011; Silvertown, 2009; Whitmarsh, Seyfang, & O'Neill, 2011), *Science communication* (with a journal dedicated to it), *Scientific citizenship* (Irwin, 2015; Jack Stilgoe, 2009), *Science in Society* and *Responsible Research and Innovation* (Owen et al., 2012; von Schomberg, 2013), *Public engagement in Science* (Delgado et al., 2010; Wilsdon & Willis, 2004), and *Citizen Science* (in all its past, recent, and emerging forms); and approaches such as *user-centred design*, *value-sensitive design*, *democratic governance*, *open innovation*, *participatory-based engagement*, *co-creation*, etc. It is not within the scope of this review to detail the differences between these. However, borrowing from Friedmann (1987), I present a framework that helps to categorise/conceptualise these perspectives and approaches and thus situate DIY enquiry as part of the practice of self-reliance. Presenting DIY enquiry within the macro perspectives on engagement also connects it to a larger societal context to shed light on what factors contribute to how practices unfold (or not).

4.2.1 Linking knowledge to action

Friedmann (1987) proposes a useful categorisation of the major theoretical traditions concerned with how best to link knowledge to action – or how to link theory to practice to organise our societies: *in societal guidance* and *in social transformation*. Although this framework stems from planning theory, the classification is useful here in that it highlights some of the general sources/origins (institutional, public, etc.), major concerns, purpose(s), political tendencies, and assumptions of public engagement approaches. These two categories, which I explain next, are intersected by two broad ideologies namely *conservative* and *radical* (Figure 4.1). It is outside the scope of this thesis to expand on the latter ideological categories, however, explained in general terms, conservative ideologies confirm and reproduce existing power relations in the service of the state. Radical ideologies range from seeking the transformation or transcendence of existing power relations (e.g. revolutionary transformation with state as necessity; neo-liberal reforms; a shift from government to 'governance'; etc. (Friedmann, 1987; Irwin, 2015) to the total rejection of power (e.g. utopianism and anarchism). The four categories in this model are not mutually exclusive; as Friedmann (1987) argues, the world is not "prisoner of only one mode of linking knowledge to action" (p.75). Next, I apply these categories to public engagement.

Approaches *in societal guidance* seek to institutionalise practice and make action by the state more effective. In general terms, the roots of approaches *in societal guidance* include *policy analysis* and *social reform*. *Practice* is considered a 'scientific endeavour' based on scientific paradigms to inform but also limit politics and there is strong belief in applying 'scientific knowledge' to public affairs. Approaches *in societal guidance* are chiefly concerned with professional responsibility: those that are not informed must be protected but they are also considered 'intrusions'. Experts devise tools or instruments to be used by the state 'in the public interest'. Engagement approaches *in societal guidance* are informed by a *policy analysis* perspective, which is based on a technical orientation that focuses on assessment and projections to inform goals and objectives. 'Best solutions' are calculated by using appropriate science theories, mathematical techniques, and measurable criteria such as economic variables, behavioural trends, environmental impacts, technical innovations, etc. (Friedmann, 1987). The aim is to control uncertainty and therefore limit controversy. Critics of these approaches frame them as having science and knowledge at their core but as being driven by scientific institutions that are often state-led and a centrally controlled. Therefore, it is argued that they ignore different forms of engagement – especially if these cannot be

measured and/or controlled (Cunningham-Burley, 2006; Irwin, 2006, 2015; Lave, 2012; Brian Wynne, 2007).

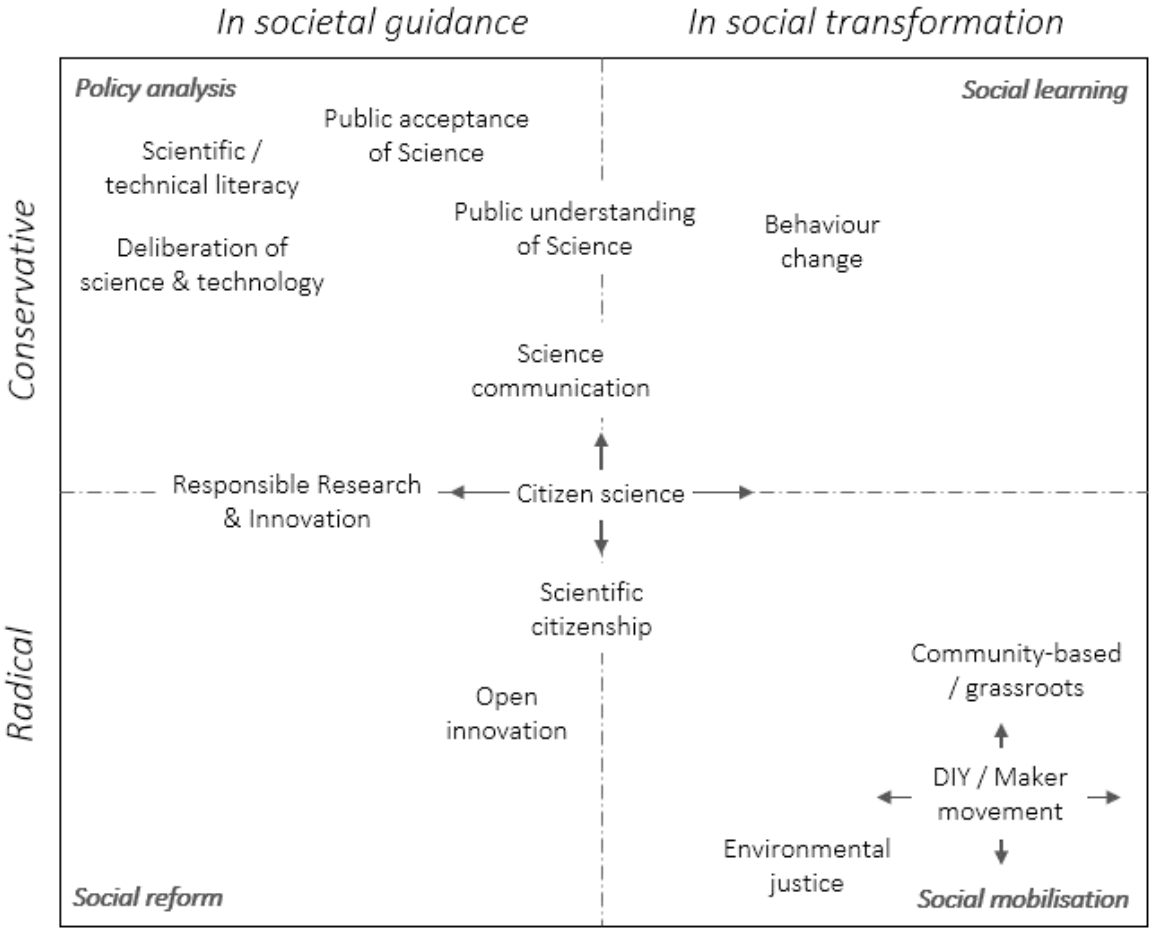


Figure 4.1 Approaches in public engagement in science and technology in a four-quadrant model. Based on (Friedman, 1987).

Approaches *in social transformation* have their roots in several schools of thought: *scientific management* (technocratic control to safeguard public interest from the 'self-serving' interests of politicians), *pragmatism* (e.g. Dewey's scientific politics - learning from social experiments), *historical materialism* (belief in a socialist state born out of working class struggle 'crushing' power relations), *Frankfurt School* (of Critical Sociology concerned with radical critique esp. of technical reason), and *utopianism* and *social anarchism* (both denying all claims of higher authority in a search for a world of non-hierarchical relations). Approaches *in social transformation* are further divided into 'social learning' and 'social mobilisation'. In *social learning* knowledge is derived from experience, it is validated from practice, and therefore it is an integral part of action. Dewey's 'scientific epistemology', for example, places emphasis on 'learning by doing'. A Marxist approach places emphasis on not only interpreting the world

but changing it. Social learning is a critique to and action against a top-down managerial approach to social organisation. It represents the practice of public engagement in science and technology with the dual purpose of serving as 'societal guidance and scientific endeavour' and as 'social transformation' with emphasis on organised and planned methods, individualism and choice, and efficiency. Theorists in this tradition assert that social behaviour can be changed and that the scientifically correct way to affect change is through social experimentation, careful observation of the results, and a willingness to admit to error and to learn from it (Friedmann, 1987). The main concerns of social learning can be generalised as: motivation to change and participate in social experiments (e.g. Agyeman & Angus, 2003; Burch & Robinson, 2007; Codagnono, 2012; Maisonneuve et al., 2010); linking formal and informal ways of knowing in a process of change-oriented action (e.g. Bonney et al., 2009; Irwin, 1995; McCallie et al., 2009); narrowing the gap between theory and practice of engagement in change-oriented action to achieve mutual learning (e.g Bull et al., 2008; Delgado et al., 2010); techniques that facilitate relations of trust and dialogue (e.g. Cunningham-Burley, 2006; Irwin, 2001); and having generalisable or universally applicable techniques for engagement (e.g. Rowe, 2005; Silvertown, 2009; Wiggins & Crowston, 2011).

For critics of institutional approaches to public engagement such as Stilgoe (2014), Wynne, (2006), Thorpe and Gregory, (2010) 'consultation' (especially 'in societal guidance') does not mean 'rethinking their policies' but rather, convincing their audiences and gaining their trust over a particular matter. They also critique that reaching 'consensus' has meant more 'extracting public opinion' and masking the diversity of views and voices than reaching an agreement over a particular issue (Beebeejaun, 2016a; Stilgoe & Lock, 2014).

Jalbert (2011), Irwin (2015), Stilgoe and Lock (2014) concur in that rather than opening up discussions and arenas for decision-making, 'public dialogue' actually leads to closure by willingly or unwillingly excluding or preventing the emergence of alternative views and solutions. This is akin to Bijker et al.'s (2012) 'technological closure'. Barnett et al., (2012) explain that the disconnection between publics and institutions lies in that rather than publics being engaged with, they are imagined by institutions. Hence, public need is not contingent on public responsiveness and therefore the use and development of engagement mechanisms are often a function of those specific characteristics attributed to imagined publics. I discuss this creation and perpetuation of social illusions in Chapter 5.

The *social mobilisation* perspective, on the other hand, stems from an assertion and commitment to 'direct collective action from below'. Approaches in this perspective start from a social critique and primarily focus on social transformation through radical politics (Friedmann, 1987). In contrast to theoretical perspectives of social reform and policy analysis (see Figure 4.1, p.78), which are concerned with management of change 'from above', social mobilisation questions existing power relations and serves emancipatory values conducted without the mediations of 'Science' (Feenberg, 2002; Friedmann, 1987). Ideologically, approaches in *social mobilisation* are influenced by Marxist struggle, utopian communitarianism, and neo-Marxism calling for advocacy (stemming from emancipatory social movements) (Friedmann, 1987; Smith et al., 2017). The theories and perspectives in social mobilisation fall under two broad categories, namely, theories of participation and community engagement (i.e. public participatory approaches, community-based research, participatory action research, community science, and cultures of participation), and perspectives on 'politics of disengagement', and 'confrontational politics' (e.g. Hacker Culture, DIY manifestos, etc.). For Friedmann (1989) concerns of social mobilisation include: issues of leadership and the role of community organisers (e.g. Christens & Speer, 2015; Davies et al., 2012); emancipation guided by collective decision-making (e.g. Clark & Illman, 2001; Fortun & Fortun, 2005; Reason & Bradbury, 2007; von Hippel, 2005; Bissen, 2012); tolerance for open dissent and non-manipulative methods of group organising (Davies et al., 2012; Elam & Bertilsson, 2003); self-trust and freedom from oppression (e.g. Fals-Borda, 2001; Fischer & Shipman, 2011; Paulos, 2009; Robinson, 2009); development of strategies and tactics, arenas and choice of actions (e.g. Bissen, 2012; Chidgey, 2014); self-reliance, experiential learning, and learning-by-being (Emerson, 1841; Mann, 2014; Wehr, 2012); and what the relative importance given to inclusive social order and dialogic processes should be (e.g. Feenberg, 2002; Habermas, 1984; Jalbert, 2011; Leach & Scoones, 2007).

Irwin (2015) notes that in traditional, institutional-led approaches means and ends of engagement are mismatched or often not discussed openly. In fact, as I discuss in the next chapter, it can be argued that some approaches 'in societal transformation' are a direct response to this imbalance (Wehr, 2012). For example, 'civic science' (Fortun & Fortun, 2005) emerged as an institutional approach intended to question the state of things rather than to simply serve the state (p. 50). A more recent approach is 'civic technoscience', which focuses on not only understanding but transforming how and who can make scientific knowledge that is credible and actionable by reclaiming, repurposing, and redefining technologies used for scientific research (Ottinger et al., 2011; Wylie et al., 2014).

Figure 4.1 (p.78) situates a few approaches in public engagement in a four-quadrant model. The quadrants represent conservative ideologies confirming and reproducing existing power relations serving the state; radical ideologies that range from transformation or transcendence of existing power relations to total rejection of power; a state-centred approach 'in social guidance'; and an 'in social transformation' approach supporting inclusiveness, participation, and action from 'below' or 'the fringes'. The boundaries between categories are fluid and the illustrated approaches are neither exhaustive nor mutually exclusive. Citizen science and DIY movement are shown with arrows extending toward all quadrants; as I describe next, adherents to these approaches have a varying range of standpoints and concerns.

4.2.2 Conceptions of engagement in citizen science

Citizen science is a rich and growing area of both study and practice. It offers a multiplicity of frameworks, models and examples that can help situate DIY enquiry. In general terms, citizen science describes the many ways that the public is engaged in science: from crowdsourcing, obtaining data from a large number of people via the Internet, often without compensation (OED), to collaborative science, in which people are involved in problem definition, data collection and analysis in a project (Haklay, 2013a).

As discussed in Chapter 3, engagement in enquiry and development of tools for exploration is evident throughout history whether done by independent and dedicated amateurs, through recruitment, or by ordinary citizens hired as data collectors (MacGregor, 2011; Miller-Rushing, Primack, & Bonney, 2012; Sagan et al.,1980). It is argued that much of the engagement and enthusiasm for exploration/discovery remains the same over time. However, the difference today is the scale at which it is happening, aided by ICTs, manifested as a growing diversity of efforts with a range of (still little understood) potential impacts, as discussed in Chapter 3. The term 'citizen science' was first used in 1989 by the Audubon Society to describe their grassroots acid rain data-collection as a 'citizen science' programme (Kerson, 1989). It has since been used in a multiplicity of contexts. For example, Bonney used the term 'citizen science' in 1995 within the field of ecology to refer to the "growing number of scientist-driven public research projects" at the Cornell Laboratory of Ornithology (Bonney, 1996, in Bonney et al., 2009, p. 15). At the same time, from a sociology of scientific knowledge and environmental policy perspective, Irwin (1995) employed the term to discuss the "difficult relationship between science, society and the environment"

inclusive of more contextual forms of knowledge and understanding (p. x). In the last decade, citizen science has gained popularity in many fields: astronomy, ecology, humanitarian relief, social science, science communication, etc. Hence it is not surprising that citizen science initiatives stem in all ideological, procedural, and technical directions (as illustrated by the extending arrows in Fig. 4.1).

One of the tensions within citizen science is the divisive difference between lay and professional expertise. As discussed in section 2.5.1 (p.45), this difference was exacerbated by the professionalisation and institutionalisation of science. Efforts to 'reconnect' science/technology and society emerged in the mid-20th century with efforts such as the Festival of Britain and 'public consultation' in the 1980s and 1990s (Bloomfield et al., 2001; Dickinson et al., 2012; Irwin, 1995; Jardine, 2013). However, with an 'in societal guidance' approach in citizen science these tended to function within a culture and practice of institutional science that did not often question the epistemological assumptions they employed. For example, in terms of the knowledge produced, what and how it is produced and the ownership over that knowledge continues to not be explicit or examined. Thus, they are bound to produce and even perpetuate a system of technocratic difference and knowledge divides (Kuhn, 1962; Slaton & Abbate, 2001). The critique of the 'in societal guidance' approach is its adherence to a 'normative, objective, impersonal, and value-neutral' framing of science and its instruments (Miller-Rushing et al., 2012; Ravetz, 2006).

Irwin (2015) critiques that current dominant approaches to public engagement with science (especially those seeking to establish scientific governance) are, for the most part, merely exercises 'extracting public opinion'. Beebeejaun (2016), echoing Irwin (2015), critiques that 'consensus' often masks the diversity of the publics 'engaged' and that public engagement has become more focused on the process of engagement rather than on the ends or purpose of engagement. For Irwin (2015) the central issue is on *how* public engagement and participatory approaches have lost sight of the original problem for which a solution was being sought: in the name of what is public engagement being done – ideals or realities? I return to this in section 4.3.1.

'Public participation in scientific research' (PPSR) was originally conceived as a model to address some of these issues and in particular, the shortcomings of 'Public Understanding of Science' (PUS) in the context of 'informal learning'. As a model for citizen science, PPSR aimed to make research relevant to people's lives; if research directly affected or was

connected to people's lives and if they felt that they could directly affect the learning process, content, and/or outcomes of the experience then their motivation for engagement would increase significantly. PPSR also aimed to address the disconnection between the outcomes of PUS and the public's experience. That is, while the ends of PUS are often bound by the delivery of specific content, results, or impacts, the PPSR approach aims to help "the public experience and understand the process of research, that is, the way that scientific questions are asked, answered, and debated by the scientific community" (Lewestein and Bonney, 2004, in Bonney et al., 2009, p.10). This involves direct engagement of the public in the multifaceted and iterative processes of 'genuine' scientific enquiry described as: choosing or defining questions for study, gathering information and resources, developing explanations (hypotheses) about possible answers to questions, designing data collection methodologies (both experimental and observational), collecting data, analysing data, interpreting data and drawing conclusions, disseminating conclusions, discussing results, and asking new questions.

The PPSR model also aims to acknowledge the contribution of citizen science to scientific practice and thus highlights the niche that citizen science fills: carrying out projects that professional scientists would not do on their own because the types of questions do not advance the field or their career, the place is not of interest, the project is too restricted in scope (and therefore audience too narrow), etc. The latest revised model of PPSR (Shirk et al., 2012) nuanced five categories of engagement (Table 4.1). DIY enquiry tends to be classified as 'collegial contribution' (Silva & Krasny, 2016) because as Shirk et al. (2012) describe, "the degree of amateur participation in the research process is so extensive and independent that expert amateurs arguably adopt the traditional role of scientist-as-knowledge producer" (p. 5).

The current focus of PPSR (Bonney et al., 2014; Phillips et al., 2014) is on evaluation of long-term impacts of citizen science projects including: increased public support of science, better informed citizenry, enhanced science and environmental literacy, increased conservation of natural resources, scientific recognition of the value of volunteered collected observational data, policy initiatives that address environmental issues, etc. However, the PPSR model remains unable to integrate issues and questions about meaning, questioning production of knowledge, questioning the role of the institution, or acknowledging multiple forms of knowledge. These issues are the concern of some approaches in hacking and grassroots engagement, which I discuss next.

Table 4.1: Types of engagement in PPSR based on Shrik et al., (2012).

Contractual projects	Communities ask professional researchers to conduct a specific scientific investigation and report on the results
Contributory projects	Generally designed by scientists and for which members of the public primarily contribute data
Collaborative projects	Generally designed by scientists and for which members of the public contribute data but also may help to refine project design, analyse data, or disseminate findings
Co-created projects	Designed by scientists and members Of the public working together and for which at least some of the public participants are actively involved in most or all steps of the scientific process
Collegial contributions	Non-credentialed individuals conduct research independently with varying degrees of expected recognition by institutionalised science and/or professionals

4.2.3 Hacking and grassroots engagement

Participation in citizen science can be conceived of as a continuum of engagement, as explained by Haklay (2013a). Comparable to PPSR, Haklay's (2013a) model, depicts four levels of engagement ranging from engagement in projects with specific needs and methods predefined by scientific institutions to achieve their goals (levels 1-3 in Table 4.2) to collaborative science where the public leads the entirety of the process (from problem definition and data collection to analysis and choosing how the results will be used). In the latter professional experts act as facilitators.

Table 4.2: Types of engagement in citizen science. Based on Haklay (2012).

Level 4 'Extreme'	Collaborative Science — problem definition, data collection and analysis
Level 3 'Participatory science'	Participation in problem definition and data collection
Level 2 'Distributed intelligence'	Citizens as basic interpreters
Level 1 'Crowdsourcing'	Citizens as sensors (volunteers are dispensable and replaceable)

The characteristics typical of levels 1-3 include but are not limited to building *big data* (extremely large data sets that require computational analysis to extract insights). The concerns and characteristics of level 4 are citizen-driven research (which include the use and co-development of tools for enquiry), empowerment and inclusion, and the recognition of

contextualised 'informal' and local knowledges (not necessarily in the geographic sense). A critique of 'collaborative science' is that it has more practical applications than being productive in generating peer-reviewed publications (Dickinson et al., 2012, p. 291). This critique betrays its standpoint and highlights the importance of Irwin's (2015) concern: in the name of what is public engagement being done?

Linked to this model, but critically addressing the 'democratising potential' of technologies, Haklay (2013b) presents a hierarchy of hacking (Figure 4.2) consisting of 4 types: meaning hacking, use hacking, shallow technical, and deep technical hacking.

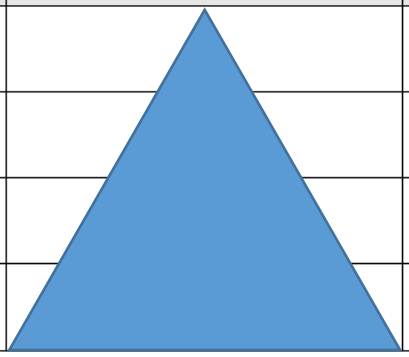
Type	No. of participants	Engagement issue
Deep technical hacking		Significant skills, negotiation, & translation of knowledge
Shallow hacking		Skills, user/programmer, control over application
Use hacking		Knowledge of web apps, legitimacy of outputs, access to data & software
Meaning hacking		Outputs, legitimacy of interpretations, overcoming 'technophobia'

Figure 4.2 Levels of hacking, based on Haklay (2013b).

In this model *meaning hacking* occurs when users reinterpret information and applications that they find, for example online, providing it with a new context and meaning different from that for which it was intended. Haklay (2013b) explains that the hacking here is more conceptual than technical. In *use hacking* people reuse some of the technical functionality of a device or system appropriating it for a new purpose. Here the hacked application or system is not only imbued with new meaning – its functionality has also been altered. In *shallow technical hacking* systems are reconfigured and organised to provide a new social meaning as for example, in the merging of various systems into one new system to provide a new service. Here, higher technical aptitude is required. In the case of 'mashups', the integration of information from multiple systems, one needs the aptitude to manipulate computer code, the technical ability to do so, and the time and resources. However, Haklay (2013b) argues that this type of hacking can be performed without necessarily having a deep understanding of the technology as new configurations are made easier through for example, Application Programming Interfaces (APIs). *Deep technical hacking* involves the creation of new systems that are capable of opening new political and social spaces and requires changes to existing

technical codes. Haklay (2013b) gives the creation of OpenStreetMap as an example of this allowing the production of free geographic information that is accessible to anyone and for any purpose. He notes that this level of hacking requires very significant technical knowledge to create tools and managing systems. The skills required for this are in the hands of "a small technical elite within society" (p.66). This model is akin to Fischer's (2011a) model of social creativity in *cultures of participation*. He argues that to bring social creativity alive, cultures of participation need to be fostered and supported with socio-technical environments in which all stakeholders are able to express themselves, combine different perspectives, and generate new understandings. These environments are facilitated by meta-design that allows stakeholders to move from unaware designers to engaging as contributors, designers, and ultimately (albeit in dwindling numbers) decision makers in personally meaningful activities that extend the range of their environments (Fischer, 2011b).

Ciborra (1992) argues that it is at the grassroots level that core competencies and skills are daily deployed and perfected because it is here that solutions are embedded in everyday (tacit) experience and local knowledge (section 2.6, p.48). He argues that grassroots is "the petri dish for tinkering", where creative applications that have strategic impact are invented and tried out (p.305); it is where learning and innovation are both incremental and radical. Similar to Reason and Bradbury's (2008) 'many ways of knowing' (Chapter 2), the relevance here for public engagement is an acknowledgement of everyday practices because the ideas and innovations people pursue (not only in DIY) shape and are nurtured by our everyday concerns, habits, and motivations (Jardine, 2013; Reason & Bradbury, 2008). This links to considerations for an analytical inclusion of the social and personal practices in the contexts that shape them (section 2.3, p.40).

While Ciborra (1992) mostly referred to institutional innovation, others argue that the difference between grassroots and professional engagement is not quite clear-cut. For example, Martin (2005) defines 'grassroots science' as science done by people outside mainstream professional science including research carried out by amateurs and lay people as well as some dissident work by professional scientists. He states that both professional and grassroots science involves the creation and use of systematic knowledge, using standard procedures, within a community of practitioners, and involving both theory, experiment, and bricolage. Martin (2005) highlights that the value held by grassroots science is that scientific knowledge is public knowledge and it is this reclaiming of ownership that links grassroots science with activism. I explore this further in the next section. There are various examples

of community-based social mobilisation in the literature illustrating how citizens take action in seeking knowledge, carrying out bottom-up responses to environmental and humanitarian disasters and accidents, and thus effecting change with grassroots science and activism (e.g. Aldrich, 2012; Gigler & Bailur, 2014; Norheim-Hagtun & Meier, 2010). For Jalbert (2011) the critical component in community-based participatory research (CBPR) is an emphasis on capacity building across hybrid partnerships to form robust coalitions for a common cause – key aspects of an approach 'in social transformation'. Unlike focus groups or public inclusion methods, he argues that CBPR acknowledges different kinds of expertise and its role in mechanisms prioritising issues and forming solutions[4].

For Powell (2016) the DIY and hacking culture operates by undermining and appropriating systems and structures through material practice in a 'social mobilisation' approach countering power and authority. She argues that the significance of hacking is in the valorisation of participation as both a feature of exercising authority/ownership and a way of engaging with institutional power. It is also significant in how it evokes accessibility and a material or ideological transformation of technical and scientific knowledge production. This is akin to Haklay's (2013b) argument that in some cases, deep technical hacking also involves a deep change in meaning and attitude. For Coleman (2012) hacking is a journey characterised by the consequence of constant occupational disappointments and personal/collective joys, which build not only social and technical capacity but a heightened sensitivity for individual expression. Powell (2016) suggests that hacking culture has indeed made a difference in ideas about how to produce open knowledge and hardware, but that the outcomes of that production, as Morozov (2014) also pointedly argues (and countering Ciborra's (1992) view), have not always produced the radical openness that hackers (and others) seek. However, Irwin's (2015) question remains: in the name of what is enquiry being carried out – ideals, aspirations, commitments…? And where are these situated in relation to the contextual issues they were originally trying to address? These lead to further questions about the purpose of engagement: what and who is it for? Is purpose dynamic/emergent (and therefore challenging to track)? Is/should there be a split between the means and ends of engagement? These questions are at the root of some of the challenges in public engagement.

[4] It is important to note where these different approaches are situated: around the creation of specific types of knowledge. For example, PPSR is linked to ecology and natural sciences, much of CBPR is based around issues of health, Public Participatory GIS is linked to urban planning knowledge etc.

4.3 Challenges in public engagement

4.3.1 Limits to engagement

For Haklay (2016) our understanding of participation needs diffraction to nuance issues of ownership, inclusion, and meaning. In terms of data ownership Haklay (2016) notes that it is not often the case that the data remain under the control of those who create it. In the case of ownership over technology and data collection methods, especially those based on ICT, an imbalance in ownership is inherent when significant technical expertise and resources are needed to set up and maintain the system. Further resources are needed for large scale monitoring initiatives and to interface with collaborators and users. This is linked to considerations for the role of technology developers, who, through design choices, ultimately have control over who participates e.g. choice of operating systems or assumptions about political circumstances where the tools might be used. Another aspect Haklay (2016) highlights is recruitment tactics, or how people come to be engaged. For example, the process can be one of self-selection, and therefore exclusive, if the tactic only 'preaches to the converted' (Blake & Tucker, 2005; Tidwell, 2012). In the case of promotion through social media channels, these might be visited by those who are already prone to participate or have related interests thus limiting new audiences. A final consideration raised by Haklay (2016) is the issue of meaning in understanding practices of participation. Here, meaning is linked to both a framing of legitimacy and the significance that participation has for those involved. Haklay (2016) and Nold (2015) argue that on the one hand there is overreliance on sensors and/or collection devices and on the other, there is a tendency de-emphasise the inadequacies of sensors and methods used to avoid a negative impact the legitimacy and level of engagement. One of the issues that arises is linked to the way expertise and authority are valorised at the societal level. Haklay (2016), as did Jalbert and Kinchy (2016), argues that the reliance on sensors and 'tangible' data such as decibels as 'legitimate' ways of measuring noise reflects this valorisation; there is as 'a need' to capture a number because it is the norm. Numbers are given more weight than the use of our sense of hearing, and our discomfort – because 'numbers' normalise and objectify 'feelings' or both.

Powell (2016) highlights the difference between the value placed on the processes of participation (means) and the value of expanded accessibility of knowledge (ends) in the practice of hacking. She notes that the data produced by bottom-up groups/individuals is valued differently depending on which form of authority the group/person is associated

with. Based on this Powell (2016) highlights an interesting relationship in tension: when the processes of participation (means) are given preference over accessibility of knowledge (ends) then the legitimacy of institutional science is reinforced by the fact that the data collected by inexpensive sensors are often of poor quality or not comparable with data produced by scientific institutions.

Another concern that Lewestein (2016) raises is that the different labels (e.g. hacking, community-based participatory research, grassroots science, etc.) mask the expanse of practice under the umbrella of citizen science. For Klein and Kleinman's (2002) the consequence of fragmentation of 'relevant social groups' (p.59) is that few practitioners or scholars realise how broad the practice/field is and thus the diversity that there is in engagement. Bonney (personal communication), on the other hand, calls for a unification of these different groups/practices into a single, stronger voice. However, while there might be truth in that there is 'strength in numbers', the reasons – whether we know them or not – for why practices have different names should not be underestimated, for example, 'peer-to-peer' emphasising the agency in collective teaching and learning (Grodzinsky et al., 2006), or 'civic science' as a type of science that questions the institution of science on which some citizen science and engagement models are grounded (Fortun & Fortun, 2005). A call for unity creates tension between diversity on the one hand and legitimacy and purpose on the other. Lewestein (2016), for example, questions whether participation in the diversity of citizen science practices somehow changes the way science is defined and understood. He notes that while citizen scientists are learning science, they are simultaneously challenging scientific orthodoxies and making claims on the governance of science. However, what type of 'science' is being learnt or how science is being challenged is left unanswered.

A related issue is that of legitimacy of practice and the distinction between participation and 'critical difference' of which Beebeejaun (2016) warns. In the eyes of the authoritative validator, the lack of documented examples often amounts to lack of evidence to 'prove' (and therefore legitimatise) the contributions of citizen-led or grassroots initiatives. At the same time these 'good' examples of mobilisation, Beebeejaun (2016) states, should not be mistaken for a significant shift of power towards citizens. She links this to Arnstein's (1969) stark reminder in her influential 'ladder of citizen participation':

> There is a critical difference between going through the empty ritual of participation and having the real power needed to affect the outcome of the process. […] In most

> cases where power has come to be shared it was taken by the citizens, not given by the city (p.216).

Beebeejaun (2016) warns that not acknowledging the expanse and diversity of practice deepens inequalities. As with Lewestein (2016) and Thorpe and Gregory's (2010) concern, a quest for generalisable and replicable 'best practice' masks the context and situatedness that gives rise to diverse practices. In fact, it renders these 'extracted' best practices flawed if removed from the context within which they unfold. It is this context that reveals some of the preconditions needed for particular initiatives to be successful (how and for whom). As Bijker and Pinch (1987) remind us, stories of innovation are incomplete without a thick description including failure and controversy. If stripped of meaning and if told only from the 'winning side' these success stories also run the risk of masking the current discrepancies and the limited influence citizens have in decision-making (Rydin, 2013). However, this highlights Kuznetsov and Paulos' (2010) argument that it is not only institutional practices that mask struggle but also individual practices; by only sharing finished prototypes and successful projects – the stories of those who failed and their contexts/situations are left untold.

One of the factors driving the search for good practice and stories of impact is the commitment to frameworks and funding structures. However, for Reason (2006) participation is not something to be achieved and measured merely in numbers of people reached but rather as an emergent process of human association. Emergence is not a phenomenon, it is a characteristic that takes time to develop as people develop trust in themselves, others, and their capacities to respond as I pointed elsewhere (Regalado, 2016). Thus it requires addressing and confronting power and politics at the level of groups and organisations (Heron & Reason, 2008; Reason, 2006). Emergence means acknowledging that initial questions, relationships, purposes, and what is important may change over time (Reason & Bradbury, 2008) – but can one embrace this emergence while asking 'in the name of what is engagement being done'? Can this shed light on the difference between 'established' or traditional practices of enquiry and grassroots or DIY practices? For future research it would be interesting to understand emergent enquiry in a resource-rich environment, for example 'blue sky research', in comparison to the practices and results from emergent DIY/grassroots research without direct access to institutional resources and structures. Could the latter be in a better position to understand and address power relations and a different kind of knowledge production? In the next section I describe some of the opportunities that have arisen for DIY enquiry and practice.

4.3.2 Opportunities for engagement

Bonney et al. (2014) attribute the growth of citizen science projects to the role of the Internet in everyday life. The opportunities that arise from this, they argue, are that projects gain substantial visibility, functionality, and accessibility. Additionally, advancements in web-tools and accessible interfaces also enable previously marginalised groups to contribute to citizen science. They note that the development and use of appropriate protocols, training, and oversight, provide opportunities for volunteers to collect data of quality equivalent to data collected by experts.

In addressing some of the more technical limitations to engagement, examples include co-designing data-collection tools and engaging in their calibration and the planning of the data collection strategies. However, meaningful participation, Haklay (2016) argues, comes from control over the use of the data collected. Reason and Heron (2008) argue that meaningful participation also comes from acknowledgement and ownership over the consequences of the use or the data collected. It also comes from the significance or narrative of the whole engagement process, which is what gives personal and community ownership over the process; contextual narratives are what connect data and the purpose of engagement because it is what gives both data and participation meaning (Haklay, 2016; Heron & Reason, 2008).

In terms of legitimacy and impact, for Bonney et al. (2014), the benefits of citizen science and their aspirations for it are conflated: projects that 'truly do science' and are open to the same system of peer-review that applies to conventional science can in fact produce reliable data and information usable by anyone, including scientists, policy-makers, and the public. While they do not point which undesired aspects of academic peer review to avoid, they do suggest that projects should be designed to include comprehensive research methods and ways to monitor these methods (examples of which they provide). Bonney et al. (2014) and Crowston (2015) see an opportunity to address the critiques against quality of data produced by citizen science: by developing and incorporating open-source approaches to data management and data analysis tools, rigorous evaluation, and opportunities for professional development.

Powell (2016) highlights a tension between the strong focus that DIY/grassroots efforts place on 'engaged communities and accessible tools' and the 'production of scientific knowledge commons', which she argues, is an overshadowed secondary focus. Silvertown

(Silvertown, 2009) also notes that scientists are using citizen science more as mode of environmental monitoring education when its opportunity lies in creating large-scale scientific knowledge.

However, while the considerations by Haklay (2016), Reason and Heron (2008), and Bonney et al. (2014) show a way to address these tensions, the barrier is still that considerable resources are needed to overcome them. Yet, Bonney et al. (2014) maintain that collaborations between professional scientists, government agencies, and communities can fulfil this while also leading to the establishment of practices that cover a range of interests – including community-driven questions. Similarly, Conrad and Hilchey (2011) hold that the benefits of community-based monitoring (CBM) initiatives are in facilitating increased environmental democracy through information sharing and increased scientific literacy through broader community or targeted public education.

Linked to Powell's (2006) tension between means and ends of engagement, Silva and Krasny (2016) note that few grassroots initiatives monitor their efforts and impacts and that this lack of documentation precludes the adaptation of practices based on outcomes; i.e. it hinders both production systematic process/methods and scientific knowledge commons that can also guide practice. As we've seen in Chapter 2, Bunge (1966) and others noted that knowledge gained from experience is not always explicit nor articulated, which renders it not readily usable: does not lend itself to learn from failures and it is hard to test. However, Silva and Krasny (2016)argue that for those that do collect data on their practices and monitor their impacts on local communities and ecosystems, there are several opportunities to a) create tools and protocols for enquiry that are accessible and b) build partnerships between DIYers and professional scientists in a way that leads to more intensive resource sharing and production of scientific knowledge.

Kera notes that as DIY movements grow and their activities begin to take shape, they have the potential to form a global culture with alternative networks of knowledge production and sharing, offering a more resilient and pragmatic response to various challenges. This, Kera (2012) adds, is manifested not only through an ethos of open data and a range of protocols and DIY kits but through spaces – or 'hackerspaces'. She argues that these function as 'intermediaries and transnational sites' between academic science and research and the everyday interests, practices and problems of ordinary people in diverse local contexts. How and why is not explicit in her text but links to what Kemmis and McTaggart (2005) describe

as 'communicative spaces' – physical, virtual, intellectual, and cultural spaces that acknowledge civic agency and nurture the collective expertise that strengthens and supports civic agency, seeing them as ingenious and capable of devising locally adapted solutions (see also Regalado, 2016).

Conrad and Hilchey (2011) also identify several benefits of CBM including the building of social capital through volunteer engagement, connections to agencies, building of community leadership, capacity for problem-solving and identification of resources – given there is access to appropriate guiding information and expertise. They argue that while CBM can garner local community support and promote engagement at various stages they do not have a diverse representation (e.g. are mainly activists) and they often struggle with credibility and capacity. Yet, Conrad and Hilchey (2011) note that CBMs are more successful when they match government's agenda to be more inclusive. Thus, CBM can support or drive proactive changes to policy and legislation and further yet, serve as an early warning/detection system on which authorities can act.

Similar changes are spurred within institutional practice. As mentioned above, Fortun and Fortun (2005) described a change in research attitude within toxicology – not only acknowledging interdisciplinarity but also the breaking free from dominant power to create a type of science that questions the state of the world, rather than simply serving the interests of the state. Furthering this conception within the context of social justice, Ottinger et al., (2011) describe how science and engineering have been transformed by technical experts' encounters with environmental justice activists. This is akin to Stilgoe's definition of citizen scientists: "All scientists are citizens, but not all scientists are Citizen Scientists. Citizen Scientists are the people who intertwine their work and their citizenship, doing science differently, working with different people, drawing new connections and helping to redefine what it means to be a scientist" (Jack Stilgoe, 2009, p. 11). Also raising questions about the scientific practices and identities of technical experts, Ottinger et al., (2011) argue that those who work with environmental justice organisations become activists themselves or change their practices by sharing scientific knowledge and know-how with communities. They further note that while the 'transformation' of these activist-experts has been challenging, there are now various examples of mainstream institutions and agencies where environmental justice concerns have been, at least partially, internalised and institutionalised as a response to ongoing environmental justice activism. Campbell Keller (2009) illustrates numerous examples of scientists who act as political advocates influencing policy. Wylie et

al., (2014) describe a similar transformation of civic action but for the formation of new types of institutions. They explore the relationship between the academic institutions and new public formations of scientific research. These public formations leverage tactics in the practices by critical making communities to directly question and transforms who has access to and controls production of credible and actionable knowledge.

The opportunities for DIY practices range from technical arrangements to social conditions. The Internet and open source software enables community-driven questions and facilitates building scientific and technical literacy. At the same time meaning and ownership are gained by connecting data, processes, and infrastructure to purpose. Legitimacy and impact can be achieved by putting in place monitoring and evaluation protocols and by establishing and nurturing partnerships that have the potential to redefine institutions, roles, and the purpose of engagement in enquiry – in both an approach 'in societal guidance' and 'in social transformation'.

In this chapter I have presented some of the different theoretical approaches and arguments on public engagement with science and technology and have situated them in terms of standpoint on practice based in Friedmann's (1987) epistemological model linking knowledge to action I also highlighted relevant challenges and opportunities in public engagement literature on practice. I now bring these together and offer a useful model to inform the study of DIY enquiry within public engagement.

4.4 Public engagement in DIY enquiry

Public engagement can be conceptualised at the personal, group, institutional, and state levels (Figure 4.3). While these levels overlap, there are a few factors associated with the development of public engagement at each level. For example, key factors influencing public engagement at the *state level* (operating 'in societal guidance') include government commitments to effective state action. The state pushes forth and justifies a conception of engagement 'for the common good' led primarily by the scientific establishment. This provides stability and resources to produce substantial datasets that offer societal benefits. It can, for example, aggregate personally collected data (e.g. from self-tracking) to provide better healthcare and public services more acutely targeted to our needs. Here collective science is extracted from information provided individually to support research that would

not have been possible otherwise (hence feedback loop in Fig. 4.3). At the same time, this data is not always provided voluntarily or does it equally befit society.

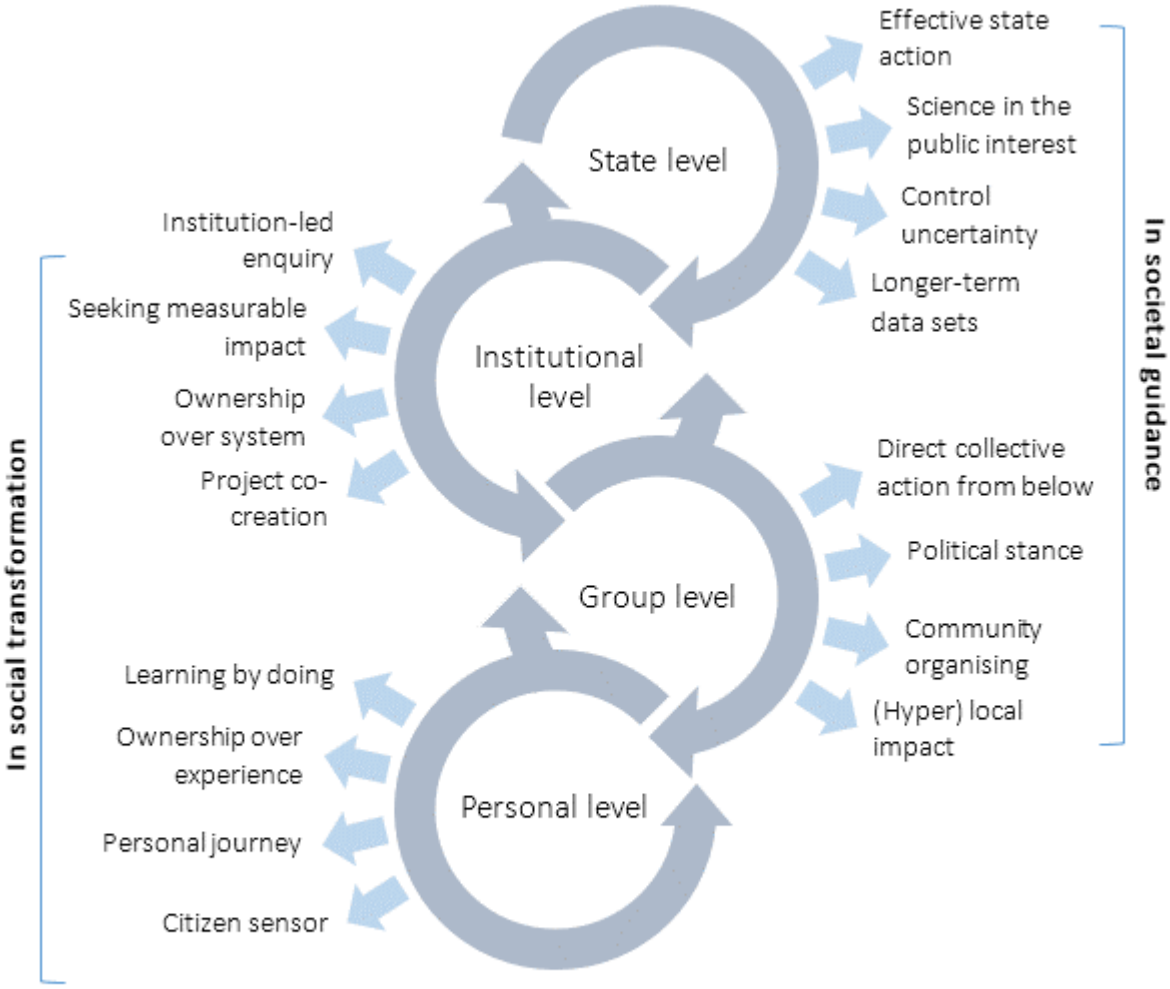


Figure 4.3: Modelling the literature on Public Engagement to inform the study of engagement in DIY enquiry

At the institutional level factors include commitments and frameworks that shape practices to public engagement. Part of these obligations involve monitoring impact and replication of good practice. At this level, partnerships and collaborations are sought and groups and organisations (co)create spaces and projects through sharing of know-how and assets, provision of funding, etc. Ownership over system (Fig. 4.2) also plays out at this level, where deep technical hacking is supported by infrastructure and resources and can build the institutional capacity of grassroots and institutional establishments alike.

At the group level strategies from both 'in societal guidance' and 'in social transformation' approaches are leveraged. Community organising seeks action for change at various levels,

including state level. In doing so, groups take political stances, yet, impact is often at the hyperlocal scale.

At the personal level there is a search for self-reliance and development of competencies through learning by doing. There is ownership over enquiry, learning, and making as a personal journey. At this level individual engagement can range from serving as data collector or citizen sensor contributing to a predefined/established project to being a project catalyst. DIY enquiry occurs and is influenced by factors at these various levels. Hence, to study it and understand its practice, it is useful to consider the interplay between these levels and the larger concerns, purposes, political tendencies, and assumptions under which these operate, that is, 'in societal guidance' and 'in social transformation'.

I now move onto presenting the theoretical framework, which brings together insights from these three literature topics, namely 'kowledge' (Chapter 2), 'technologies' (chapter 3), and 'engagement' (Chapter 4) to offer a 'hypothesis' on the factors hindering and enabling public engagement in DIY enquiry.

5. Theoretical framework: DIY enquiry and practice [5]

This chapter presents the theoretical model for DIY enquiry as a hypothesis for what factors contribute to the possibility of public engagement in practices of DIY. It draws from the previous literature review chapters in a way that brings their focus topics (Figure 1.1, p.21) together to create a tool for analysis of DIY enquiry. This theoretical model guides the initial research dimensions of the case studies and it is then tested against the theoretical integration models of the case studies (section 7.5, p.162).

5.1 Situating practices of DIY enquiry

The main premise of this research is that DIY and grassroots approaches to investigation and experimentation have the potential to address local concerns in which tools and media act as vehicles for making sense of the world in people's own terms – i.e. they incorporate different ways of knowing, understanding, and doing into their material, discursive practices. There is evidence that it is through the bottom-up envisioning and devising of methods and through the creation, repurposing, and use of technologies, that some people are taking a lead applying their civic capacities into investigative and problem-solving initiatives. By questioning and challenging the state of things, these efforts are enabling people to take issues of concern into their own hands (Jalbert, 2011; Wylie et al., 2014).

At its core DIY means taking ownership over learning and action, having the confidence in our abilities to do, and thus, becoming more self-reliant. In his 1841 essay on self-reliance, champion of individualism and transcendentalist, Ralf Waldo Emerson expressed his dissatisfaction with the lack of autonomy among the American population betrayed by a dominant dependence on experts and reliance on institutions.

The term *Do-It-Yourself* and its abbreviation 'DIY' came into use in the 1950s with the advent of hobbyist magazines such as Popular Mechanics and Mechanix Illustrated (McFedries,

[1] A large proportion of this chapter appears in "Getting out of their way: Do-It-Yourselfers, sensing, and self-reliance" (Regalado, 2016).

2007) but DIY in itself is not a new phenomenon nor is DIY a generalisable culture. Nevertheless, a useful conceptualisation is one of DIY as both a *philosophy* and a *movement*. As a philosophy it stands for freedom from the reliance on institutions to discover our own motivations within (Wehr, 2012, p. 2) and as a movement, DIY draws from an intellectual infrastructure that allows DIYers to reflect on what it means to do-it-yourself (Morozov, 2014). Together these form the foundations of a DIY ethos that is reflected in various DIY manifestos (Frauenfelder, 2010; iFixit, 2010; McCue, 2012).

People across the world are engaging in DIY for a multiplicity of reasons; interests and motivations range from conscious and politicised responses to a complex and fast-moving world, to the pride of having a job well done, to wanting/needing to save money (Wehr, 2012). Focusing on DIY as a movement helps us make sense of this social phenomenon, whether it is collective, coordinated, or individual, intentional or not. As Wehr (2012) argues, "the collective behaviour of multitudes of people in a particular direction certainly deserves notice" (p. xii). It is a movement which, in recent years, has gone from the margins to the mainstream (Barba, 2015; Cole, 2011).

What characterises texts on DIY practice is 'DIY electronics' and 'physical computing', that is, the use of programmable devices, often connected via (wireless) sensor networks, that interact with and respond to input from the surrounding environment e.g. sound, light, radiation, gases, etc. This is also known as DIY sensing and can be linked specifically to the Maker movement, "movement of people who take charge of their lives, solve their own problems and share how they solved them" (Roscorla, 2013, p. 1). There is also an element of aesthetics and artistry involved as it is not just about 'doing-' but 'designing-it-yourself' (Lupton, 2006). It is precisely this increase in the availability and affordability of platforms and components as well as the vast array of online resources that is said to enable DIY sensing, which many claim is contributing to the 'democratisation' of science, technology, knowledge production, and the web. In this research, the practice of DIY refers to the use and development of DIY technology in the broader sense to include not only the tools, such as sensing equipment, but also the reflective processes involved in making sense of environmental sensing itself – that is, DIY techniques.

Looking at DIY practice in this way – as a philosophy, movement, process of making, reflection – opens up the issue of who controls, consumes, and creates the means for participation in it (Kelty, 2005; Ratto & Boler, 2014b). Kelty's (2005) idea of social

imaginaries, grounded in Charles Taylor and Jürgen Habermas' theories on 'the public sphere' (see Box 1), helps to bring together DIY, enquiry, and self-reliance: he explains that social imaginaries are ways in which people imagine their social existence through their practice, how they fit together with others, the expectations that are normally met, and the deeper normative notions and images that underlie these expectations (Kelty, 2005). As spheres of common practice, these imaginaries permit us to understand DIY as a form of 'free speech'. In this way DIYers and first-timers alike use technologies as a kind of argument to make claims: they make arguments about DIY and they also make arguments through it and the artefacts they create embody these claims. That is, DIYers create meanings and express ideas about DIY through discourse but by physically *doing* they also *express* ideas about the process of *doing*; expressing by doing is also a means for ideals to be conveyed, practiced, shared, and repurposed. For example, a map made using DIY aerial photography showing the effect of an environmental disaster can convey the extent of the environmental damage, while in a more subtle way, the making of the map relays something about how the map makers envision the practice of taking ownership over the issue – and eventually, enables them to take control over that issue (Keysar, 2017).

Argument-by-DIY[6], as equivalent and in parallel to argument-by-discourse, whether it is written or verbal, says something about how self-reliance, self-learning, and self-satisfaction takes shape. In this way, DIY provides a voice that not only counts in the decision-making process and in the problem solving of local issues but also shapes the discourse of 'taking ownership' and 'taking issues into our own hands'. Thus, DIYers can be conceived of as agents who, in a call to engage in a critique of the system, are redefining civic responsibility and are creating the means to investigate, interpret, and change their environments. In the next section I take a closer look at how argument-by-DIY highlights the power of people's capacity to act as civic agents. I explore what people are able to express through DIY practice and how the implications of that can be understood in terms of larger social structures. What does DIY as an expressive social imaginary tell us about its ideals, hopes, aspirations, motivations, and what does this reveal (or conceal) about the inclusivity and exclusivity of current practices – for the individual and in terms of the larger societal structure?

[6] Akin to Kelty's (2005) idea of 'argument-by-technology'.

5.2 Technology and the Colonisation of the lifeworld

Throughout human history various technological advancements have led to improvements in the quality of life (e.g. vaccination), access to information (e.g. printing press), connection with and understanding of the micro- and macrocosms (e.g. microscopes and telescopes), etc. However, over the last century the rate and scale of technological advancements and innovations, as well as the processes by which they are produced, have also contributed to the mystification of a large part of human lives, especially in advanced economies (e.g. electronics and pharmaceuticals).

Digital and mechanical objects aid and mediate everyday lives, yet, they are for the most part taken for granted; it seems that very few people feel they understand how their devices and artefacts function and fewer yet feel they know much about how these are made, where, and by whom (Bijker & Law, 1992; Wehr, 2012). This 'alienation' and 'mystification' of technologies was conceptualised more than 150 years ago by Karl Marx, who was critical of the effects that new forms of industrial labour had on society, specifically, on social relations. He explained that in the new labour system, the interactions between the worker, the product, and the consumer, which had previously been of a social nature, were being replaced by wages and prices. According to Marx, in the wage labour system the labourers were separated from what they produced – its quality, meaning, and value; the product was mass produced, sold anonymously in the global market, and hence, it grew mystified as its origins became unknown or forgotten. Marx argued that when money mediates social relations, we experience detachment: a separation from the fruits of our labour and from what is being produced – there is a lack of appreciation and of personal fulfilment. As a consequence, a loss of sense of ownership, pride, choice, and even hope is experienced.

Jürgen Habermas, a contemporary sociologist and philosopher in the tradition of critical theory and pragmatism, both critiqued and advanced Marx's ideas of alienation, detachment, and mystification in industrialised societies. He pointed out that liberation from the forces of production and emancipation cannot be conceived by conceptualising labour as the basic category of human liberation; human relations and interactions are 'subject-to-subject' in nature, whereas relations between labour and work are merely instrumental, that is, object-to-subject (Finlayson, 2005). Additionally, Habermas observed that in small-scale societies people employ their social competences, what he calls *communicative action*, to negotiate with each other and create meaningful relations – person-to-person. For Habermas the concept

of communicative action entails not only the establishing or maintaining of social relationships between people (Edgar, 2006) but it also emphasises his point on *agency*: people are indeed social agents capable of affecting change. Unlike other sociologists and critical theorists[7], Habermas refused to accept the pessimistic idea of people as passive victims at the mercy of a powerful force; he rejects that the capacity of ordinary people to debate and challenge authority or the status quo can be wholly suppressed and instead, looks to emerging sources of critical potential such as social movements that appeal their stance.

Box 1: The public sphere as ideology

The public sphere is "an intermediary between the public realm of the state the private interests of individual members" – "not merely as a way to bring together the voices of many private individuals but also in so far as it facilitates the articulation of the individual's sense of self". As an ideal, publics interact in the public sphere, where "open and rational debate between citizens form public opinion". However, "while it articulates itself in terms of an ideal such that all citizens may contribute to the debate, in practice, that ideal is compromised" – the working classes, women, ethnic minorities, etc. are excluded and this therefore entails that a number of fundamental issues and discourse are not only excluded from the debate but are not politically recognised (Edgar, 2006, pp. 124–126; Ratto & Boler, 2014).

Following Edgar's (2006) analysis on Habermasian thought, let's then argue that the content of the ideology of the public sphere is symptomatic of the concerns of the oppressed. Ideologies have utopic content – like dreaming of a better world. However, just as psychoanalysts find clues in their patient's dreams as to what is bothering them rather than taking the dreams literally, so can ideologies, as imaginaries, be treated as symptoms of the state and the societal context in which it is conceived, thus providing important clues as to the forms of oppression taking place. These 'clues' provide guidance as to what can be done to remedy and change the situation.

Habermas contrasted small-scale with large-scale societies and observed that as societies grow and become more complex in their arrangements (e.g. to undertake grand projects such as welfare, national transport networks, a space programme, etc.), larger, state-driven mechanisms of coordinated actions are established to mobilise the scale of people and resources needed. He argued that these great projects have the benefit of facilitating the relatively smooth running of societal functions while relieving the population's competencies to achieve and engage in other, perhaps other more complex activities. However, he adds that these 'relieving' mechanisms come at a price. To function, they require increasingly complex networks of highly distributed and asynchronous groups of people. Habermas argues that the approach in these relieving mechanisms, what he calls *instrumental action* (in contrast to communicative action), is characterised by coercive action and causal intervention

[7] Specifically his tutors Theodore W. Adorno and Max Horkheimer from the Frankfurt School.

with manipulation of the physical world. In this sense, the instrumental action in these relieving mechanisms makes use of commonly recognised *cues* (e.g. regulations, monetary value, status), which people use/respond to without the need of resorting to communicative action (Edgar, 2006, p. 18). That is, without the need/ability to negotiate or share/create meaning, thereby impoverishing 'reflective practice' (Van Manen, 1977, section 2.2.2, p.37).

Habermas notes that while the instrumental approach might seem an effective way of running a complex system (e.g. by simplifying interactions between people and artefacts), problems begin to arise when "people cease relating to each other […] as communicatively competent human beings, and instead, treat each other as means to an end" (Edgar, 2006, p. 18); the same cues that smoothen the running of society take over the functions and ways of relating with each other in our everyday life. For example, when I walk into a shop, I examine and choose my items (e.g. based on their monetary value) and place them on the counter. The common cue is the price: the shopkeeper conveys it and expects money for it; I pay and leave the shop. Our interaction was mediated by predictable cues and we considered each other mainly in terms of means to an end. Taken more broadly, money and the mechanisms of capitalism shape the Internet and digital technologies and these in turn shape us (McChesney, 2013); we internalise (and take for granted) its functions and cues and this shapes our behaviours and culture[8].

Habermas focuses on the characteristics and effects of these cues and identifies them as 'steering media'. These media function as coordinating and directing mechanisms for the 'system', i.e. the social institutions and structures of our societies: money is the steering medium for the capitalist economy; power is the steering medium for the state administration and related institutions. Power, Habermas argues, functions in a similar way as money "in so far as those who have legitimate power can both compel others to behave in a certain way […] and can delegate power to others, so that subordinates can themselves control others. Again, communication is not required, providing the chain of power goes unquestioned, and the subordinate obeys the order as expected" (Edgar, 2006, p. 19). For Habermas it is not merely the functions of money and power that pose an issue when they extend outside the system, but what they come to signify in our societies: "[P]ower needs an additional basis of confidence, namely, legitimation […] [and] requires an advance of trust that not only 'compliance' – a de facto obedience to laws – but 'obligation' – a duty based on the

[8] It would seem that we would not speak to anyone because algorithms 'learn' and can tell us exactly what we need…

recognition of normative validity claims (Habermas, 1987, pp. 270–271). Here it is easy to see how the professionalisation of science follows the same rationalisations: it has the power, legitimacy, and mechanisms to abide by, test, recognise, and disseminate a particular approach to knowledge and its production; it is established, perpetuated, embedded, and unquestioned (esp. structurally and institutionally). These *normative validity claims* or rules aim at simplifying simplify social interactions (e.g. a legally binding contract that dictates the relationship between a tenant and a landlord or funder and principal investigator). Additionally, these rules have a high degree of consistency and uniformity, which makes them 'efficient': easier to follow, implement, monitor, and reinforce[9]. They give the system its own autonomous logic rooted in fairly stable bureaucratic institutions that have inertia and are difficult to change. For Habermas the problem is that once complex societies are organised through systems, the autonomous logic of those systems will begin to direct what is possible and how anything is achieved within that society e.g. whose knowledge counts as valid. With this framing, it is easier to see the implications of what Habermas calls the *colonisation of the lifeworld*: what is not conceived of by the system will be eventually absorbed into it (e.g. the commodification of DIY tools and spaces) or marginalised (e.g. safety risk arguments or perceived bioterrorism used against biohacking).

The colonisation of the lifeworld is a process in more complex societies by which individual freedom (of movement, thought, speech, action, and other choices) is undermined, as large-scale social processes become increasingly autonomous and restrict actions of those who are subject to them (Edgar, 2006). For example, when social interactions are replaced by wages and prices, the opportunities that promote enquiry and reflection, as well as the mechanisms for transmitting and interpreting ideas and narratives become supplanted. On a grander scale, the effect of colonisation results in the perpetuation of 'illusions', socially necessary, yet "false beliefs assumed to be true because virtually all members of society are somehow made to believe them" (Finlayson, 2005, p. 11). For example, the illusion or general belief in that technologies are advancing at tremendous speed and that the new wave of web-based tools and ICT is a force ushering democratisation but in practice, there is still a massive digital and technical exclusion underpinned by larger systemic issues (Haklay, 2013b; Morozov, 2014).

Habermas argued that through communicative action people question ideas and justify their own arguments through appeal to reason. Linking back to his argument in defence of

[9] For example, it is easy to understand the consequences of not adhering to a contract or not paying at a shop.

people's capacity to act, he employed the term *lifeworld* to highlight the underestimated competence of ordinary people to act as civic agents and to correct the bias that overemphasised the coercive power that the structures and arrangements of society have on the individual. Theodore Adorno's idea of a 'totally administered society', which Habermas wants to rectify, was representative of the dominant conception of the early members of the Frankfurt School of Thought and American sociologists of the 1960s. Habermas was concerned about the impact that autonomous bureaucracies and the capitalist economy of large-scale and complex societies was having on individual freedoms. In the backdrop of a critique of Marx, he also saw that society was created and sustained by human actions, rather than only being a product of modern technology and industry (Misa et al., 2004). For Habermas, the *lifeworld* represents the everyday world that we share with others; it is a type of social imaginary through which we envision our social experiences and which provides the cultural resources used to make sense of, cope, and adapt to life's circumstances (Edgar, 2006). It symbolises the informal, unmarketised domains of social life: networks of family and friends, culture, and political life outside organised parties, mass media, voluntary organisations, etc. (Finlayson, 2005). It is in these arenas that people interact – they question, network, reflect, discuss, and learn. 'Communication' is the medium in the lifeworld[10] by which these interactions unfold as conversations or exchanges both harmoniously and conflictually – through verbal or written discourse and by physically expressing and doing (Kelty, 2005). Together, these interactions create a 'stock' of shared assumptions, reasons, and background knowledge (Berger & Luckmann, 1966; Finlayson, 2005; see also section 2.6, p.48). It is also here where the process of DIY enquiry unfolds as people learn by doing and develop different ways of knowing; people create and adapt new and different knowledges, skills, artefacts, and competences to negotiate and maintain social relationships by constantly transmitting, adjusting, and transforming this 'stock' that makes up the lifeworld (Kemmis, 2008). These relationships can be sustained in small-scale societies, where people can interact face to face, converse, negotiate, and reach an understanding.

In summary, when populations grow and amalgamate the same instrumental requirements, the rules or normative validity claims that make the system operational, undermine the functions of the lifeworld: we begin to treat each other as merely means to an end. Hence, while the lifeworld is conducive to autonomy and in it people pursue self-chosen ends (with more or fewer limitations), in the system the goals are predetermined and actions are deliberately taken (by coercion or force) to achieve them. Habermas argues that certain 'social

[10] Whereas money and power are the media for the system.

pathologies' arise when the instrumental practices in the system infringe upon the system (colonising the lifeworld) – from dictating the legal status and relationship of people with the state (e.g. End User Licensing Agreements or Terms of Service), to standardising tests in schools and preferentially legitimising certain forms of knowledge over others. Pathologies include loss of meaning, withdrawal of legitimation, anomie, destabilisation of collective identities, alienation, and withdrawal of motivation. I now take a look at the way we can conceptualise the colonisation of the lifeworld and the challenges it poses to DIYers.

5.3 Factors influencing practices of DIY: A theoretical framework conceptualising issues of inclusion and exclusion

For Habermas *colonisation of the lifeworld* was the problematic result of 'an efficient system', useful in efficiently coordinating complex systems in large-scale capitalist economies, but detrimental when replacing/infringing upon every day social interactions. That is, coercive and manipulative interventions in the system damage the lifeworld by replacing the mechanisms for creating meaning and understanding between people.

I would like to draw attention to four interrelated factors that contribute to the phenomenon of colonisation of the lifeworld. These four interrelated factors constitute the elements of a theoretical framework which builds on Habermas' conception of system-lifeworld and helps to situate relevant issues of DIY enquiry (Figure 5.1, p.107). This theoretical framework enables the examination of issues of inclusion and exclusion in DIY practice at the societal macro-level (*symptoms of the state* and *status of science*) and individual micro-level (*self-trust* and *cognitive and technical mastery*). It also helps to examine the challenges that issues of inclusion and exclusion pose to DIYers and grassroots DIY communities. The framework draws from the literature in the previous chapters in a way that brings their focus topics (Figure 1.1, p.25) together to create a tool for analysis of DIY enquiry. In particular, it takes from Misa's (1992) levels of analysis of social shaping (Chapter 3) as well as Friedmann's (1987) epistemological model linking knowledge to action (Chapter 4). The model also draws from De Certeau's (in Feenberg, 2003) strategic and tactical knowledge (Chapter 3) as well as Reason's (2006) model on 'ways of knowing' (Chapter 2).

The four interrelated factors that contribute to the phenomenon of colonisation of the lifeworld are:

- *Symptoms of the State:* The generalisations at the societal level about publics' interests, abilities, passions and hopes held/fabricated by 'experts', society, and various publics themselves;
- *The status of science:* The institutionalisation of expertise and the way 'science' is perceived by practitioners of science, the state, and members of the public;
- *(Self-)trust:* The discourses and actions undertaken by the public, as individuals and groups, with regards to taking ownership over issues;
- *Cognitive/technical mastery:* The multiple levels of mastery and mechanisms that enable contribution to and manipulation of the system.

I discuss and exemplify each of these factors next and link them to 'colonisation of the lifeworld'.

5.3.1 Symptoms of the State

The first element of the theoretical framework, *symptoms of the state*, facilitates an examination of the generalisations, at the societal level, about publics' interests, abilities, passions and hopes held/fabricated by 'experts', society, and various publics themselves. It also helps us to unveil, as we shall see below, the hidden ideologies of a culture or practice and the socio-political discourse that shapes it and is shaped by it. This in particular links to instrumental practices and social illusions in colonisation of the lifeworld.

In current practice the state (central government or authority) supports and is sustained by steering mechanisms that coordinate the smooth running of our societies – following an 'in societal guidance' approach (section 4.2.1, p.77). As argued in the previous section, issues arise when the instrumental approach ('efficient' means to an end) embedded in the system's mechanisms interferes with the way we create meaning and relate to each other in our everyday lives.

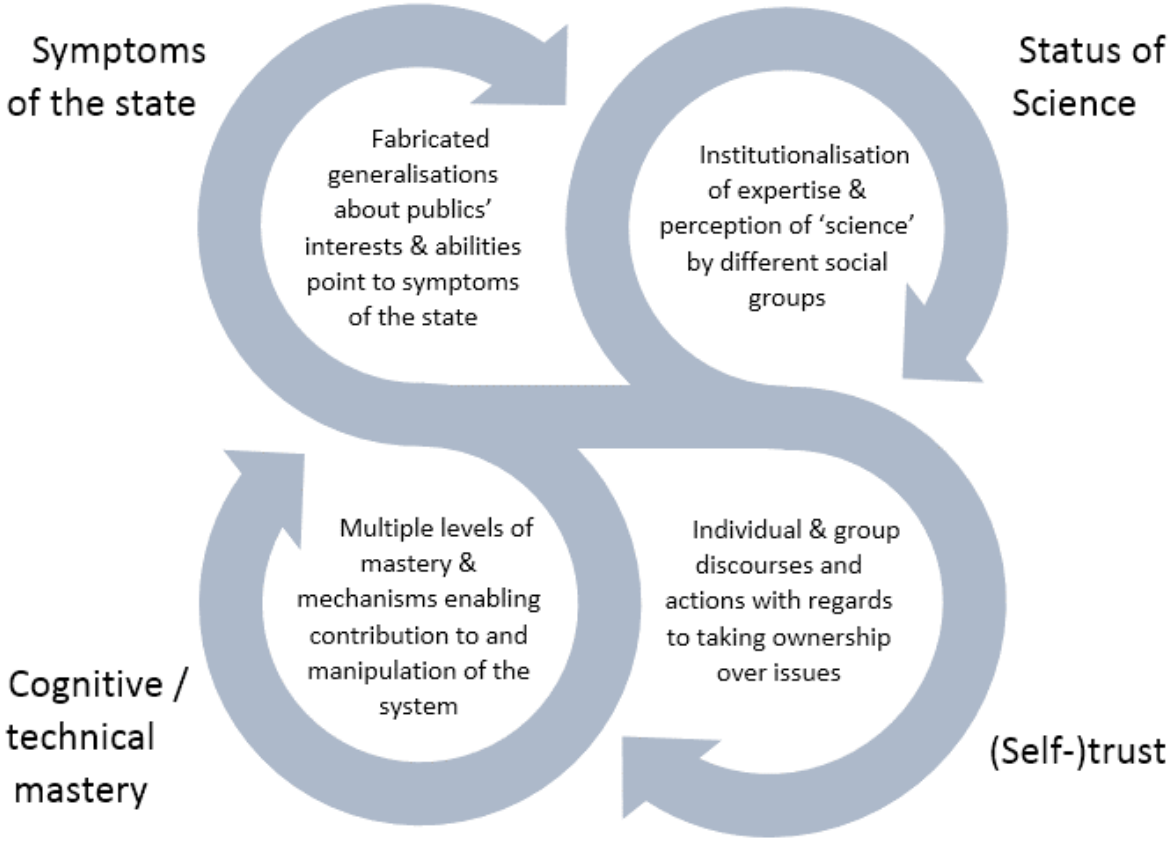


Figure 5.1: Theoretical model on factors contributing to the possibility of public engagement in practices of DIY enquiry.

Let us assume that the social/political/economic/judicial arrangements of the state are deemed too complex to be fathomed as a whole by any one individual or small group. Further, let us assume that this might partly explain why for these people the system appears too difficult to be significantly changed. If the colonisation of the lifeworld is partly symptomatic of this semi-fatalistic conception (that we are too small to understand and change the clockworks of the system), then the opposite can also be argued: that the DIY movement, consciously or unconsciously, is a symptom of the colonisation of the lifeworld; it is a politicised response to state and market. In Wehr's (2012) words, "DIY is an attempt to decolonise the lifeworld" (p.8). This analysis does not only aid in the identification of (in this case) a fatalistic conception. If we take a structuralist approach, responses to social complexity are unavoidably linked to the particular institutionalised patterns of power and authority within which they are conceived – as suggested by Winner (1986a). Deeper analysis reveals these links. For example, let us take the case of the Welfare state as ideology based on the democratic "principles of equality of opportunity, equitable distribution of wealth,

and public responsibility" (Wikipedia, 2014). Its ideology would seem to recognise the concerns of "those unable to avail themselves of the minimal provisions for a good life" (ibid). But the 'clues' of this ideology (Box 1) actually reveal a paternalistic conception of the public: one that strips them of agency (because the state makes decision 'for the common good of all'). Hence, in asking 'who decides who gets which welfare benefits?' this analysis can uncover actions in response to it (which I return to at the end of this section).

If the states' generalisations are left unexamined, the illusion and perpetuating rhetoric of 'democracy' in mechanisms such as the Welfare state become taken for granted. This is problematic because despite having a sworn allegiance to 'democracy' (e.g. House of Lords, 2000), in current institutional practice an uncritical approach not only ignores the complex challenges of sustainability in our time but also undermines the needs, knowledges, ingenuity, and ability to respond that a large portion of the population can potentially bring (Hartley, 2016). Furthermore, these generalisations by the state permeate our culture and pose several challenges for Do-it-yourselfers, DIY enquiry, and practices of techno-scientific self-reliance. First, the implications of a generalised public; second, the implications of ideology on practice, and third, recognition. I explain these in turn.

The generalisation of the public poses a challenge at the larger societal scale (as depicted by the upper loops of 'society' and 'state' in Figures 3.1 (p.73) and 4.3 (p.95) respectively). When addressing 'public concerns', and especially coming to terms with grassroots initiatives, questions posed by institutions and authorities revolve around what qualifications 'the public' have to engage with expert issues or how much they must be educated or trained to bring them up to standard (Wynne, 2007). There is still a pervasive normative process led by 'experts' who determine what the relevant 'public issues' are and hence, know what the pressing 'public concerns' are (Wynne, 2007, p. 109). Often hidden behind assurances of safety and dependability 'in societal guidance', and supported by standards and codes[11], the system's institutions establish their authority defining whose expertise (credentials, as discussed below) and agendas are valid. Authorities also fabricate a generalised conception of public needs (e.g. smart cities, science literacy, public acceptance of science, etc.) (Gauchat, 2010; Ruivo, 1994; Shaw, 2002). An 'in societal guidance' approach (described in section 4.2.1, p.77) can yield longer-term datasets to guide practice and portray stability and certainty. However, its enforced stance of 'effective state action' and 'science in the public interest'

[11] See Slaton and Abbate's (Slaton & Abbate, 2001) account of how the 'hidden life' of standards and specifications conceals the production and reproduction of distinct relationships between expertise and authority and who is left out of the process.

(Figure 4.3, p.95) in fact highlights the ultimate power that governmental 'control over framework for engagement' brings (Irwin, 2006). While research and methods are being developed to give more voice to 'lay' people and integrate public values into policy debates (Rowe, 2005b), the issue is still being approached top-down. The implication of generalisation 'in the name of efficiency' is the perpetuation of an approach that marginalises and masks the diversity in grassroots and DIY initiatives (Beebeejaun, 2016; Stilgoe et al., 2014). This in turn, deprives people of influence and importance but most detrimentally, it deprives them from a belief in that they can and should take control over issues around them (discussed in the section on issues of (self-)trust below). That is, it prevents them from beginning and therefore engaging in the process of citizen-led enquiry.

A second challenge for DIY practices concerns the critique that current strategies for public engagement often target and prioritise the open-minded, or 'innocent', members of the public over those who have existing 'activist' views. This, it is argued, leads to a model of democracy in which polarisations are avoided via 'strategic' marginalisation (Irwin, 2006). In view of a government enthusiastically subscribed to a 'science-led society' (the powerhouse of innovation) "what scope can there be for dialogue when the direction is already set?" (Irwin, 2006, p. 316).

The ideologies of a practice or culture (e.g. laboratory science) are embedded in socio-political discourse. In the context of technologies Hecht and Allen (2001) remind us to not ignore or dismiss the ways in which public conceptualisations of technology themselves serve political or cultural functions; that is, how politicians, cultural critics, policymakers, and other public figures have leveraged the symbolisms and relationships between power, authority, and technology. It is easy to take for granted the role that actual people play in producing and reproducing this discourse (and therefore create symbolisms) of power linked to technology – expressed through actions and choices. However, just as institutional practitioners imagine publics, so too do members of the public imagine institutions, authorities, and their members.

Hecht and Allen (2001) remind us that beliefs about how a particular practice operates in the world point to the ways in which these practices perform power. Grassroots and DIY practices are not free from exclusionary issues of power (Dunbar-Hester, 2013) but they provide nuanced alternative discourses, information (e.g. environmental data), solutions (e.g. environmental monitoring prototypes), and insights into the symptoms of the state. As new

practices emerge, it is useful to remember that ideas form pervasive discourses, often as generalisations – but these must be understood as an integral part of the social and political life these practices. It is through citizen-led enquiry that generalisations can (perhaps should) be scrutinised – enquired into – to not only to critique them but also learn from and shape them.

The third challenge is that to gain recognition DIY practices need to amass success stories as cumulative evidence of their impact. This challenge includes questions about how these stories are captured, where, and how they should be shared to achieve a wider reach or impact. However, Beebeejaun (2016, p. 8) warns against the challenge of generalisation when institutions seeking to 'extract' (or the system seeks to absorb) *best practices* devoid of meaning to inform policy:

> The quest for best practice has decontextualised accounts from the communities and places in which they are situated, seeking to deliver easily replicable toolkits of participation as if the solutions was innovation and not engaging with the stark evidence of deepening inequalities, with a diverse and multiple set of publics.

There is growing evidence that some grassroots initiatives, including DIY practices in environmental monitoring, are not only questioning the system and challenging the larger societal structures that underpin them but are also taking issues into their own hands (e.g. Breen et al., 2015; Hargreaves & Hartley, 2016; Mann, 2014; Wylie et al., 2014). Yet, some of these are underpinned by the 'status of science', the next factor in the colonisation of the lifeworld.

5.3.2 The status of science

The second element of the theoretical framework, *status of science*, facilitates an examination of the institutionalisation of expertise, including the way 'science' is perceived by practitioners of science, the state, and the public. It also helps us to ask questions about the relationship between knowledge and power and role of knowledge in creating barriers and opportunities for engagement.

The professionalisation of – and therefore the exclusivity of – expertise alienates and even discourages people who might consider their enquiries not up to the 'standard' of 'real'

science (Wynne, 2007). As early as the onset of laboratory science in the mid-1800s people echoed Emerson's critique: "I am ashamed how easily we capitulate to badges and names, to large societies and dead institutions" (Emerson, 1841). Most professional scientists follow rigorous benchmarks and standards and their work is governed by structures and mechanisms (e.g. funding schemes and protocols) that provide continuity and efficiency (see middle loop in Figure 3.1, p.73). As discussed above with the case of standards and codes, scientist's credentials are seen to guarantee a degree of quality and therefore occupy a position of authority. There are numerous examples where this arrangement has consistently facilitated valuable accomplishments (Good & Shymansky, 2001). However, the configuration of this same hierarchical and bureaucratic structure, which gives stability and continuity to scientific endeavours, also hinders the questioning of the structure itself and the system within which it operates (Kuhn, 1962). The status that professional science has achieved can be conceptualised as an illusion perpetuated by discourses on canonical expertise resulting in its legitimacy as the singular authoritative voice informing policy. In political discourse it represents an ideology: 'the superior public knowledge' for the greater good (Friedmann, 1987; Wynne, 2007). Freidson (1986) raises issues about knowledge and power in this context and critiques that 'knowledge' is often treated as a disembodied entity as its content is constructed by quoting textbooks, speeches, or articles in professional or lay periodicals. However, he also noticed that despite the apparent authority that professional knowledge carries, it is not as canonical as it may appear. Freidson (1986, p. ix) explains:

> [d]own at the level of everyday human experience, in schools, prisons, scientific laboratories, factories, government agencies, hospitals, and the like, formal knowledge is transformed and modified by the activities of those participating in its use. Thus the paradox that, while the institutionalisation of knowledge is a prerequisite for the possibility of its connection to power, institutionalization itself requires the transformation of knowledge by those who employ it. The analysis of scientific and scholarly texts can be no substitute for the analysis of the human interaction that creates them and that transforms them in the course of using them in a practical enterprise.

The recognition of this taken-for-granted loop in the transformation of knowledge is a key process from which DIY enquiry hinges: praxis has the power to perpetuate or change institutions. Critical of the ideological dominance of 'science' as a singular type of knowledge, Habermas defined 'scientism' as science's belief in itself: "that is, the conviction that we can no longer understand science as one form of possible knowledge, but rather we must identify knowledge with science" (Habermas, 1986a, p. 4). In response to scientism, and to dissolve the boundaries of knowledge privileged as 'scientific', Habermas identified three inclusive

categories of alternative processes of enquiry namely, the empirical-analytical sciences, the historical hermeneutic sciences, and the critically oriented sciences, which I briefly explain next.

The *empirical-analytical sciences* incorporate technical-cognitive interests for the purpose of enhancing prediction and control, e.g. the air quality modelling used by the UK's Department of Environmental, Food, and Rural Affairs to predict pollution concentrations in places they do not monitor directly. This hypothetico-deductive approach allows them to evaluate air quality policy, assess compliance with EU Directives, and to inform negotiations on policy changes (uk-air.defra.gov.uk). The *historical hermeneutic sciences* incorporate a practical cognitive interest with the purpose of improving mutual understanding. The goal of this kind of enquiry is to facilitate communication; at its core is a process of making sense of the world and it requires the mobilisation of socially mediated processes of interpretation. For example, a citizen science project, might begin with a question on how participants make sense of their role in the project and what the results mean to them. Within the historical hermeneutic sciences approach, further enquiry during the project would explore "how this meaning is historically and culturally embedded within a wider set of social norms and values" (Willmott, 1997, p. 319). The historical hermeneutic approach reveals ways in which people's skills, expertise, or ideas might be employed differently or how they could use the results in other ways. As highlighted by Nold and Francis (2016), this approach embodies a general acknowledgement of expertise that is not based on the quality of technological sensors. *The critically oriented sciences* incorporate emancipatory cognitive interests with the purpose of transformation; they represent "the calling into question, and deep-seated wish to throw-off, relations which repress you without necessity" (Habermas, 1986b, p. 198). Habermas argues that this critically oriented enquiry is fuelled by "a desire to assert the possibility of greater autonomy and responsibility" (Willmott, 1997, p. 319); akin to Freire's 'critical consciousness'. So, instead of seeking to model air pollution or only interpret the role of participation in a citizen science project, this approach reveals "how patterns of behaviour and meaning are conditional upon the reproduction of structures of domination [e.g. validation of knowledge by accredited experts] that, potentially, are open to challenge and change" (Willmott, 1997, p. 320). Willmott (1997) argues that it is this critical enquiry that reveals hidden concerns or attitudes (e.g. lack of participation interpreted as indifference towards science). While Habermas did not see these working together, these attitudes are symptomatic of structures producing and reproducing power relations (e.g. discourses and

forms of knowledge that privilege one type of expertise: an engineer's assessment versus the insights of a local resident about the level of noise pollution in their community).

Habermas' critique of dominant knowledge structures and his proposition acknowledging three different types of enquiry that complement each other are still relevant today – I discuss this in Chapter 14. Other scholars also call for plurality, a more nuanced acknowledgement of different ways of knowing as we have seen in section 2.4 (p.42). Their call for change comes in response to a paradigm in which the usual approach to managing social and biophysical systems is to simplify them to 'objective' models and controlled experiments that reduce uncertainty (Funtowicz & Ravetz, 2003; Irwin, 1995). Funtowicz and Ravetz (2003) warned that this paradigm ignores the challenges of sustainability in our time in which facts are uncertain, values are in dispute, stakes are high and decisions are urgent – what they call post-normal science (PNS) (e.g. the current state of Global Climate Change).

Returning to the colonisation of the lifeworld, an ivory tower of scientific and technical expertise becomes a problematic encroachment of the 'system' onto the 'lifeworld': problem-solving based primarily on institutionalised and professionalised science practices hinders not only our understanding of the complex and multi-scale web of emerging problems but also the conception of new methods for their solution. This is because it excludes the creativity, skills, and competencies of a large portion of the population.

In summary, the *status of science* enables an examination of the power relations in the institutionalisation of expertise and helps to ask questions about the exclusion that takes place (and the consequences of this exclusion) in the production and use of knowledge (Certoma and Pimbert's definition of it). For example, revealing that even institutional science practices are not hermetic – that in fact, the knowledge that informs those practices is transformed by those who employ it. In addition, there is a move to acknowledge different ways of enquiry and knowledge production coupled with a call for a paradigm shift. The analysis of the status of science can help to reveal that the current paradigm hinders both an understanding of complex post-normal-science issues (Funtowicz & Ravetz, 2003) and the devising of contextualised solutions. Furthermore, the lag in acknowledgement of different ways of knowing as valid knowledge claims means DIY enquiry is measured against canonical science; there is nothing else to measure it against. Status of science is influenced by the symptoms of the state, but is also deeply linked to issues of (self-)trust, as we will see in the next section.

5.3.3 Issues of (self-)trust

The third element of the theoretical framework is issues of *(self-)trust*. This element facilitates an examination of the discourses that the public, as individuals and groups, produce and reproduce with regards to initiative-taking and ownership over issues. It also enables us to ask questions about the implications of those discourses on people's actions. This theoretical framework element links to ideas of the 'lifeworld' and *communicative action* highlighting 'social pathologies as implications of colonisation (see section 5.2, p.100).

As seen in the symptoms of the state and status of science, an encroachment of the system into the lifeworld has effect at both the individual and societal levels. At the societal level, the neoliberal restructuring of society and economy emerges from and generates the fragmentation of older collective forms of identification and traditional structures. It also promotes an increased social significance placed on individual choice and action (Beck ,1992, in Reitsamer & Zobl, 2014). A neoliberal capitalist logic favours capacity for consumption over capacity for production (as we shall see critiqued in the next section) and thus it stifles a pathway into the process of enquiry and the creation of identity and sense of belonging. In the discourse of neoliberalism, the language of 'clients' and 'consumers' replaces that of citizenship (Habermas, 1984); Reitsamer and Zobl (2014) argue that civic viability (or ability to take initiative) becomes mediated by ability to consume. Here it is easy to see why Habermas critiqued the instrumental mechanisms of the system and drew our attention to the social pathologies resulting from the encroachment of the system into the lifeworld.

Returning to the creation of identity and sense of belonging... At the core of many of our accomplishments as a human species is connection to others, our environment, and through this, we construct our realities (Brown, 2010; Haste, 2004). As perceptual and susceptible individuals, we are open, consciously and unconsciously, to messages, ideas, and concepts that permeate and imprint our psyche and affect how we construct beliefs, as seen in section 2.2.1 (p.35), we create and draw from frames of reference. This in turn is based on past experiences and plays a role in directing our actions and opinions (Friedmann, 1987). Akin to Haste's (2004) conception of the 'Powerless Pessimist', the 'Learned Helplessness' model assumes that under most conditions a person will attribute a cause for life events – both 'good' and 'bad' (Saintonge, 1998, p. 583). Those who feel that *they* are the cause of things going wrong, that this will always be the case no matter what they do, and that this propensity will affect most aspects of their life, become hopeless and depressed and may give up trying

to achieve (Abramson et al., 1978; Murphy, 1980). A predisposition to feel that *others* control the good events in life have an equally debilitating effect (Seligman, 1972).

Meanings and understanding about the world are used as points of reference, which also determine an individual's ability to adapt to situations. If indeed, our education systems is stifling the individual talents, abilities, and creative thinking of too many (Robinson, 2009) and if experts' opinions of the public is that of an ignorant[12], irrational[13], and incapable[14] people, then we might run the risk of actually believing it (Bangerter & Heath, 2004; Lorenzoni et al., 2007; Wallerstein, 1992). The belief that, as individuals, there is nothing we can do because, for example, the system is too big to change, and that even if something does get done it will all be for nothing, is a debilitating and disempowering notion (Immerwahr, 1999; Seligman, 1972). The question of *why* it seems that people do not take initiative is not asked as much as how people *ought* to be engaged. In understanding the encroachment of the lifeworld by the system, these questions highlight a monumental barrier to citizen initiated and led research practices. However, as Lertzman (2012) points out, it is not apathy that we see here – that is a myth; what needs urgent attention is an acknowledgement of people's anxieties ("what is going on?"), ambivalence (competing desires and drives), and aspirations ("I want to do something about it") coupled with approaches that "meet people where they are at, not where we want them to be" (n.p.).

Reitsamer and Zobl (2014) propose a concept for exploring the process of cultural meaning production and participation: *cultural citizenship*, which "allows for an exploration of new, more individualised forms of activism and social participation at a time when [...] people are alienated from the political system and show less interest in such formal politics as voting, political parties, and political organisations" (p.332). The focus is on common experiences, discourses of empowerment, and recognition of difference as integral to articulation of identity and belonging. As with practice-based perspectives (section 2.4, p.42), there is a focus on common lexicon, meanings, and interests, which facilitate the process of enquiry – of ownership over learning and action. For Reitsamer and Zobl (2014) DIY culture "encourages individuals to make their own culture, rather than simply consuming what is mass-produced

[12] See (Friedman, 1998; Irwin, 2006; Wegener & Petty, 1998; Brain Wynne, 1992; Brian Wynne, 2006; Ziman, 1991) for discussions about conceptions of 'public ignorance'.
[13] See (Barnett et al., 2012; Eden, 1998; Freudenburg, 1993; Furnham, 1992; Michael & Brown, 2005; J. Stilgoe, 2007) for discussions on construction of 'publics' and public irrationality.
[14] See (Bazelon, 1981; Besley & Nisbet, 2013; Burningham, Barnett, Carr, Clift, & Wehrmeyer, 2007; De Boer, McCarthy, Brennan, Kelly, & Riston, 2005; Shrader-Frechette, 1990) for discussion on the public's capacity to understand and engage with science.

for them by mainstream culture industries and complaining that there are no alternatives" (p.333). It is through DIY – as practice, as enquiry, as making – that Do-It-Yourselfers can negotiate their identities – their self-trust. How exactly people even begin or take that first step into DIY is not theorised in the literature but some evidence of 'first timers' experiencing a sense of control and exhilaration is recorded in logs across time. For example: "there's a visceral satisfaction to making a physical object. But the first time I cut and spliced a piece of DNA, I felt the same joy of making something. I was like, 'Holy crap! It works!'" (Parks, 2006, p.43 in Tocchetti, 2012). Further engagement in DIY, and especially when technical DIY practice becomes Do-It-Together (DIT) or Do-It-With-Others (DIWO), invites DIYers to engage with wider questions – about race, class, gender, and power. Dunbar-Hester, for example, found that cultivation of a 'maker' identity, demystification of technology, and formation of cultural and technical production was part of media activists' practice. As activists try to promote their practice they are also grappling with the politics of defining the 'radically participatory technical identity' that underpins their practice. This ethos is liberating from authority but is also exclusionary "as electronics tinkering has long been associated with white masculinity" (p.76).

Mann (2014) proposed the term 'tinquiry', or 'tinkering as enquiry', as a playful and hands-on way of questioning and even critiquing our relationship with the world around us. For Mann (2014) 'tinquiry' kindles the willingness to "tinker, or build something, first, and then figure out what it is or what it can be useful for afterward" (p.32). In the next section I explore the realisation and awareness that comes with self-trust as it applies to our relationship with technologies in the processes of cognitive and technical mastery.

5.3.4 Cognitive/technical mastery

The fourth and last element of the theoretical framework, *cognitive and technical mastery*, points to a consideration of the multiple levels of mastery and mechanisms that enable contribution to and manipulation of the system. It also ties the framework together, showing how the symptoms of the state, the status of science, the issues of (self-)trust, and the cognitive and technical mastery involved in DIY enquiry are all interlinked at multiple levels – and across the central topics of knowledge, technology, and engagement.

The reputation of web-based tools and technologies as 'democratising' has received tremendous media coverage (see Wired, CNS, Forbes, Popular Mechanics for a few examples) and has been embraced by academic and governmental institutions (e.g. ICT4D). However, this eager hype has also undermines its critique. The reality of participation inequality, as presented in Nielsen's (2006) seminal report, is staggering: there is a 90-9-1% ratio between lurkers, occasional contributors, and heavy contributors respectively, for all large scale, multi-user, social networks. When compared to the ratio for Wikipedia users, the figures are striking: 99.8% lurkers to 0.2% occasional contributors to 0.0003% heavy contributors.

The cultures of participation model (section 4.2.3, p.84) originates from a critique of a culture that makes a clear distinction between producers and consumers and which has promoted a consumerist mind-set through media, artefacts, ways of living, learning and working (Fischer, 2011b). Fischer posits that cultures of participation can address this trend through an approach that aims at the democratisation of design. It promotes a transformation of passive consumers into active decision-makers as they become aware of possibilities, begin making contributions, organise content and mentoring, and finally become meta-designers who extend the range of their online/technical environment. They become 'smart citizens' that take advantage of smart tools to monitor, visualise, and change their behaviour (e.g. regarding their energy consumption).

This and other approaches (e.g. (Kuznetsov, 2013; Millicevic, 2007) speak to the requirements of initiative-taking both in terms of technical aspects and mind-set: there should be fertile ground that allows anyone to contribute when they want to; all that is needed is a (peer support) group and technical infrastructure (Fischer, 2011b). Specifically arguing for science, Nielsen (2012) holds that people are smart and interested enough and thus, all that is lacking for people to make a contribution is more web-based tools that give people opportunities – tools such as the online crowd-sourced citizen science projects like Galaxy Zoo and FoldIt. In the span of a generation, he argues, these tools have helped to redefine who can do science and what science is. They democratise science because "online tools are institution-generating machines" (p.158) that have the imaginative and creative *potential* to address the pressing problems of today. The key word to examine is 'potential'.

As discussed in section 4.3.1 (p.88), Haklay (2013b) questions and critiques this generally accepted and often celebrated assumption that online technologies, such as participatory

web-based geographic information tools, are bringing on a new wave of democratisation. Loosely defined around ideals of participation and access for anyone, anywhere, anytime, this assumption is based on unexamined potential rather than the actualisation of democracy. Indeed, the potential of web-based technologies and tools to bring about radical change should be applauded, as in the case of projects such as Hole-In-The-Wall in India (www.hole-in-the-wall.com/). However, as Hartley (2016) argues (section 1.4, p.25), it is not merely the potential of technologies that need acknowledgement and examination, it is also the new forms of association, disruptive interactions, and production of knowledge that come about through their use, development, and adaptation that need our attention. Together, these represent the potentiality in DIY enquiry.

Yet, the problem in models like cultures of participation is that there seems to be an assumption that 'if you build it they will come' without the need for questioning the very foundations on which they are built (or regard for who 'they' are). That is, the politics and inherent mechanisms of exclusion embedded in technologies should also be acknowledged (Habermas, 1986a; Haklay, 2013b; Winner, 1986a). And as Morozov (2014, pp. 8–9) points out:

> [O]ur institutional imagination has stalled, and with it the democratising potential of radical technologies. We carry personal computers in our pockets —nothing could be more decentralized than this!—but have surrendered control of our data, which is stored on centralised servers, far away from our pockets. The hackers won their fight against I.B.M.—only to lose it to Facebook and Google. And the spooks at the National Security Agency must be surprised to learn that gadgets were supposed to usher in the 'deinstitutionalisation of society'.

As discussed in Chapter 3, to participate, notionally accessible tools need to become actually available, and people need to feel confident using them. However, the overwhelming focus on technologies, institutions, and the system at large (ideologies and illusions) has implications for people's agency and self-reliance, as Emerson (1841) denounced more than 170 years ago; people's competence, interests, and passions (including their beliefs and attitude towards technologies) are compromised by a tendency to assume unawareness and an underestimation of their capacity to take issues into their own hands without the recourse to powerful web-based tools. At the same time, gaining significant control means acquiring a much greater technical and cognitive mastery coupled with more time and resource requirements and deep technical hacking requires infrastructure that builds and is supported by institutional capacity, which is prone to rigidity and exclusion.

I have discussed how the state, at the larger societal level, the status of science, the issues of (self-)trust at the individual level, and the issues of cognitive and technical mastery all contribute to the 'colonisation of the lifeworld'. These four combine and create complex conditions that both hinder and enable people to take part in shaping their lives. However, it is these same factors that inspire and even propel people's initiative-taking. Technologies, as argued above, have a dual function: they can create dependency through instrumental use but as claims, whether it is argument-by-discourse or argument-by-DIY, they can also spur autonomy and create new meanings, practices, artefacts, and stances. This theoretical framework is my hypothesis and it will be put to the test and adapted based on the analysis of empirical evidence from three case studies on DIY enquiry in practice, community, and place. The next two chapters outline the methodological theory and procedures for these case studies.

6. Methodological theory

6.1 Methodological overview

The primary research goal for this research is to investigate what people do through practices of DIY enquiry and what these practices do to them (1st research question) – with a specific focus on production of knowledge, the role of technologies, and the opportunities and barriers to engagement in DIY enquiry. The study of these aspects furthers an understanding of the factors that contribute to the possibility of public engagement in practices of DIY enquiry, including the development of tools and techniques (2nd research question).

As noted in the preceding chapters, the phenomenon of DIY as a "collective behaviour of people in a particular direction certainly deserves notice" (Wehr, 2012). Technologically-oriented DIY is a (re)emergent issue in the 21st century – but why now and how is it different from previous movements such as 'back to the land', the arts and crafts movement, pirate radio, or indimedia? It has been argued that technologically-oriented DIY enquiry takes a new multimodal form within the context of the digital information age in which technologies are changing; that the DIY phenomenon represents a step-change in involvement in societies with a growing percentage of people with an education and understanding of scientific and technical processes, access to open information on the Internet, and powerful mobile devices with effectual computational and environmental sensing abilities 'in their pockets'; and that through the use of networks and distributed innovation tools 'resistance groups' are challenging modern configurations of truth and authority and aim at achieving actionable goals.

I have argued that the three interrelated topics of knowledge, technology, and engagement are central to the study of DIY enquiry. Thus, a socio-technical approach to qualitative enquiry is well suited to investigate not only the factors contributing to its emergence and possibility but also the *what*, *how*, and *why* of practices within DIY enquiry. Such approach looks at context, interactions, and meanings of DIY practice at three depths: collective practice, individual activities, and socially organised place-based action.

The theoretical underpinnings of this socio-technical approach follow from the literature review: a new conceptual mix of social theories was used to provide guidance on the framing

of a theoretical framework for DIY enquiry (Figure 5.1, p.107) because there is currently no single theory that can account for the phenomenon. These theoretical underpinnings also guide directions in data collection and analysis as I discuss below.

The methodology for this research is divided into two chapters. This chapter outlines the methodological theory: methodological orientation, tradition, and design strategy of this research. An overview of these are presented in Table 6.1. The next chapter, 'methodological practice' covers the tools and procedures for data collection and analysis. This chapter also attempts to convey the research journey in coming to grips with various theories in the search for understanding a new and emergent phenomenon. It must be stressed that the design of this methodology is the result of performing multiple iterations over the last five years, which the following linear and flattened representation does not do justice in its entirety.

Table 6.1: Overview of methodology

Methodology stage	Approach / stance
Methodological orientation	Social studies of Technology; Social interactionism; practice-based perspectives
Methodological tradition	Grounded Theory
Methodological design strategy	Multiple case studies with multi-method approach for each case; Purposeful sampling

6.2 Methodological orientation: ontological and epistemological assumptions overview

Methodological orientations are types of social theories that explain the distinguishing features of social and cultural life. They guide the approach to identifying, framing, understanding, and explaining social reality. That is, they focus the research endeavour on making specific claims about ontology (what there is to know), epistemology (how one comes to know), and even axiology (one's values). In social science research these orientations stem from various concerns – from Phenomenology (concerned with meaning, structure and the essence of lived experience) to critical perspectives (concerned with changing the status quo such as Critical Hermeneutics). As many of the premises of these paradigms overlap and because new research calls for explanations to complex problems (Mihata, 2002), it is not uncommon to combine aspects/concepts of these to create a guide for new research approaches (Cheek, 2008). In the design of a socio-technical approach to qualitative enquiry

for this research I draw from a combination of theories, which I use as lenses through which to view engagement in DIY enquiry by extending and complementing the broad conceptions of constructivist and interactionist theoretical traditions. Specifically, I draw from a constructivist approach as developed by Bijker and Pinch in Social Studies of Technology (SST) and the Symbolic Interactionist perspectives based on Blumer (1969) and extended by Snow (2001) and Swan et al.'s (2007) practice-based perspective. Below I describe the ontological and epistemological assumptions of each and then present their significance in guiding the study of the practices of DIY enquiry.

6.3 Guiding ontological and epistemological assumptions in Social studies of Technology

The design of a socio-technical approach to qualitative enquiry from the perspective of SST is based on the following constructivist-interpretive and qualitative research assumptions:

1) A constructivist approach opens technological artefacts to sociological analysis: their use, design, and their technical 'content' (looking in the 'black box' of both society and technology).

2) The micro- and macro-levels of analysis are linked[15] because there are no rigid social/technical, micro/macro, and system/environment boundaries. These boundaries are 'negotiable'. Therefore, the term 'system' should not imply stability and lack of conflict.

3) Social interaction must be studied by including interactions with non-humans such as infrastructure and technical artefacts; an analysis that "restricts itself to merely social relationships will fail to pick up how technology and materiality mediate the character of such relationships" (Bijker & Pinch, 2011).

It is useful to expand on the third assumption to frame the guiding concepts and terms used in data collection and analysis:

[15] Hence the recursive arrows in the 'Society', 'Institution', and 'Individual' loops in Figure 3.1 (p.73) and the overlap of macro- and micro- over the meso-level of analysis.

Complexity. It is assumed that phenomena and the experiences or conclusions drawn from that phenomena are open to more than one interpretation. This highlights two aspects of 'flexibility': first, the multi-dimensional character of technological development – placing it in the social context of interactions and meaning negotiation; second, the heuristic purpose of this type of qualitative enquiry. The first is known as *interpretive flexibility* and assumes that technological artefacts are culturally constructed and interpreted. It also considers that there is not just one possible way or one best way of designing an artefact (Pinch & Bijker, 2011). The second highlights that the study of technological development needs to draw from both philosophical/theoretical analyses and empirical data to avoid 'moulding' data into a rigid model.

Frame. The concept of a *technological frame* assumes that there are different ways in which *relevant social groups* attribute various meanings to an artefact; frames are located *between* actors, not *in* actors or *above* actors. A technological frame is understood as a frame with respect to technology, rather than as the technologist's frame; the broadness of the term aims to be inclusive of non-experts (Bijker, 2011). In addition, the frame structures attribution of meaning – a type of 'grammar' and 'semiotic structures' that are used in the interactions of a relevant group. Technological frames are determined by actors' goals, interests, skills and training, background, etc. (ibid). This concept is also of central importance in Symbolic Interaction as outlined by Snow (2001) and Swan et al. (2007).

Interaction. A technological frame structures the interaction of members of a social group and applies to the interaction of various actors across time and space. In addition, different actors will have different degrees of inclusion in the frame and all actors will, in principle, be members of more than one technological frame. It is assumed that a technological frame is built up when interactions 'around' an artefact start and continue (Bijker, 2011). The concept of 'interaction' also bridges into and complements Symbolic Interaction from a technical perspective.

Inclusion. The concept of *inclusion* is multidimensional because 'framing' and 'being part of the framing' is multifaceted. Inclusion is time-sensitive and contextual, reflecting the dynamic character of technological development.

This research employs an empirical socio-technical approach to qualitative enquiry. In the tradition of SST, it uses *thick description* as described by Geertz (1973) (incorporating the cultural framework and meanings of the actors and thus providing an account grounded in the actors' cultural context) and as extended by Denzin's (2001) *thick interpretation*, which emphasizes the inseparability of description and interpretation. The wealth of detailed information produced about the technical, social, and political aspects of technology and technological practices are then 'simplified' into a model using procedures in Grounded Theory as I describe below. Additionally (also explained below), a methodological design based on case studies is used because it provides 'information-rich' empirical data from a multiplicity of sources.

6.4 Guiding ontological and epistemological assumptions in Symbolic Interactionism

Symbolic Interaction (SI) is a methodological orientation with broad sociological applications. Its foundational question is "what common set of symbols and understandings have emerged to give meaning to people's interactions" (Patton, 2002, p. 112). It places great emphasis on the importance of meaning and interpretation and how people create shared meanings through their interactions in a way that these meanings become their reality (ibid). SI theorises society as process by studying the creation and communication of meaning (Williams, 2008). Its theoretical foundations derive form the works of John Dewey, Charles Horton Cooley, and George Herbert Mead. However, it was Mead's student, Herbert Blumer, who in the mid-1930s published his course notes and coined the term 'symbolic interactionism'. Mead and Blumer shaped the sociological perspective on the idea that humans account for meaning in two basic ways:

- Meaning may be seen as intrinsically attached to an object, event, phenomenon, and so forth.
- Meaning may be understood as a psychological accretion imposed by people on objects, events, etc. (Berg, 2008).

The three main premises of SI as articulated by Blumer are:

1) Nothing has inherent meaning; all meaning is assigned and human beings act toward things on the basis of the meanings that the things have for them;

2) The meanings people attribute to things arise out of social interaction;

3) The meanings of things are handled in and modified through an interpretive process used by the person in dealing with the things they encounter (Patton, 2002; Williams, 2008).

Next I outline the roots, assumptions, and critiques of SI, followed, in the subsequent section, by its main critiques and a description of more contemporary approaches to SI – relevant to this study and which link back to epistemological discussions from the previous chapters.

Symbolic interactionists see society as interaction, conceptualised in a similar way as in SST. They do not study individuals; they focus on the social actions in which individuals engage. These social actions include visible behaviours between people, objects, and situations but also the inner actions such as the interpretative process used by individuals to make sense of the environment/situations encountered (Burbank & Martins, 2010). There are four underlying assumptions in SI. The first three revolve around the conceptualisation of *symbols*, *interactions*, and *human agency*. The fourth assumption has its roots in pragmatist ideology. I detail these in turn.

In SI the concept of *symbol* refers to any social object (e.g., a physical object, a gesture, a word, etc.) that stands in place of or represents something else (e.g. how, for some, "if you can't open it, you don's own it" has come to represent the epitome of DIY culture). The assumption is that symbols – or making something into a social object – are a uniquely human creation (no other animal has the ability to arbitrarily assign meaning). In addition, humans are "pragmatic actors who continually adjust their behaviour to the actions and reactions of other actors. People can adjust to these actions only because humans are able to interpret the actions of others; that is, humans are capable of denoting actions symbolically and treating these actions, and those who perform them, as symbolic objects" (Berg, 2008, p.828). People can do this because imagine alternatives and possibilities that can then guide their actions.

The concept of *interaction* intends to highlight the significance of interpersonal communication in transmitting the meaning of symbols. Furthermore, it is through interaction that culture arises, that is, the ideas, objects, and practices that constitute everyday life (Williams, 2008). It is in holding the premise of polysemy – or the multiplicity of meaning – and the power of interpretation that, despite their subtle differences in emphasis, various traditions (e.g. SI, Phenomenology, Hermeneutics) tend to agree. The parallel between them is in that meaning is actively constructed and renegotiated by social agents interacting with one another. Meaning varies across contexts, groups, and instances of speech; meaning is thus relative and open to interpretive freedom and transformation (Vannini, 2008).

Based on these two concepts an additional set of assumptions on *human agency* arise: humans are shaped by the culture into which they are born but they also have the capacity to change the structures that shape culture. That is, while culture precedes individuals' births, people are considered to be autonomous, interpretive beings who have the ability to negotiate, modify, or reject the meanings they learn, and thus actively shape culture. The significance of this is that human beings are active creators and interpreters of symbols and culture – individually and collectively, consciously and unconsciously; they draw from and shape culture.

SI has its roots in (and carries the assumptions of) the pragmatist philosophy of John Dewey, William James, and Charles Peirce. Pragmatism holds that knowledge is a process rather than a thing and that the world is comprised of many truths (pluralism). In this sense, 'reality' is conceptualised in terms of potentiality because it is assumed that human beings are selective in what they notice about the world; thus, different people may apprehend the same reality differently (Williams, 2008, p.850). Based on this, pragmatists question the role of 'science' suggesting that it is value laden. Hence, "if reality and truth are relative, then all scientists come to their research with beliefs, values, and morals that cannot simply be ignored or set aside" (ibid) – at least not completely. These premises led to a re-conception of science as a moral endeavor through which the human condition can be changed – for better or worse (ibid). Some research fields take this view. In Action Research for example, some scholars argue for a more reflective approach to doing research. Kemmis (2010) argues for developing situated understanding that is not only done for the sake of knowledge but for the sake of what happens as a consequence of our actions.

There are three main critiques of SI. First, that it is overly committed to the study of everyday life and the social formation of the self, while ignoring social structure (same critique that Pinch and Bijker (2011) received – section 3.2, p.57). Critics note for example, Mead's emphasis on the power of the actor to create reality thus, ignoring the extent to which people live in a world not of their own making (West & Turner, 2004). Second, and linked to the latter, SI is critiqued for overlooking class relations and constraints in favour of a more optimistic view of an open society (Stryker, 1987). Third, SI is criticised for its broadness, often interpreted as vagueness, in data analysis. The following section presents contemporary approaches that address some of these and in doing so, also extend and complement SI in the study of emergent practices such as DIY enquiry.

6.5 Contemporary approaches to Symbolic Interactionism

6.5.1 Extending Symbolic Interactionist epistemology

In addressing the first two critiques outlined above, contemporary SI scholar David A. Snow (2001) posited four broader and more inclusive orienting principles building on Blumer's original SI premises. These principles are: *interactive determination*, *symbolisation*, *emergence*, and an extended view on *human agency*.

Interactive determination aims to address the issue of narrow focus by asserting that "focal objects of analysis – be they self-concepts, identities, roles, organisational practices, or even social movements – cannot be fully achieved by attending only to qualities presumed to be intrinsic to them" (directly responding to the way Mead and Blumer conceptualise the intrinsic nature of meaning above). Therefore, research must consider the "interactional contexts or webs of relationships in which they are ensnared and embedded". From this perspective the significance of SI is the consideration that "neither individual or society nor self or other are ontologically prior but exist only in relation to each other" and therefore can only be understood by studying the interactions among them - actual, virtual, or imagined (Snow, 2001, p. 369).

Symbolisation refers to the processes of 'framing'; that is, they ways in which "events and conditions, artefacts and edifices, people and aggregations, and other features of the ambient environment take on particular meanings, becoming objects of orientation that elicit

specifiable feelings and actions" (Snow, 2001, p. 372). Snow (2001) extends the study of symbolisation by furthering three important questions about the process, its sedimentation, and its disruption:

- How do meanings or symbolisations become taken-for-granted and routinized e.g. turned into habitual practices or frameworks through narrative, material, habit and identity?
- What kinds of social contexts, organisational forms, relational connections, and social processes are conducive to or facilitative of the routinisation or 'sedimentation' of meaning? and
- Under what conditions and in what ways are sedimented meanings or extant cultural frames fractured, contested, or debated, thus rendering the symbolic basis for action problematic and calling for new or revitalised interpretations and framings?

The study of symbolisation in this way can help to uncover issues of inequality and thus how barriers to engagement in DIY enquiry are formed, their roots (e.g. why is sedimentation important and happen in the first place – as common language or knowledge?), and their impact on the phenomena under study (e.g. how do groups response or adapt?). This also addresses the second critique of SI in neglecting power relations described above.

Emergence addresses the critique of ignoring social structure. It encompasses processes out of which "new, novel, or revitalised social entities, or cognitive and emotional states, arise" and which "constitute departures from, challenges to, and clarifications or transformations of everyday routines, practices, or perspectives" (Snow, 2001, p. 373). Extending the pragmatist view, emergence acknowledges complexity thereby focusing our attention on *potentiality* rather than on generalisation or prediction in the study of social phenomena – especially assurgent phenomena such as DIY enquiry. For research grounded in SI, Snow (2002) calls for a focus on those moments and interactions in which emergence is at play – at the individual or collective (social) levels – because it is there where the dynamic and non-routinised part of social life occurs. This is relevant because it acknowledges the potential for change, not only in organisational and social arrangements/mechanisms but also of associated meanings and feelings (Snow, 2001).

Human agency comes to the forefront when frames of reference, what is taken for granted, or what becomes routinised is disrupted; that is, when goal-oriented action is thwarted and

when self-images or self-concepts and identities are debased or contradicted (Snow, 2001). Human agency takes shape when individuals or collectives "attend to some kind of corrective or remedial action", visible for example, as collective action in social movements. Reference groups are also linked to agency because defining a situation emerges out of social interaction with others. Reference groups are social units whose culture is used as a frame of reference in defining successive situations. These vary in size, context, and time (e.g. luddites). Individuals may change reference groups throughout life thus disrupting sedimented interpretive process (Burbank & Martins, 2010).

For Snow (2002) the epistemological contribution of SI is one that breaks down a false dichotomy in which 'agency' and culture or structure presuppose one another. In addition, the conception that human action is based on meaning and that this is derived from interaction with self and others enables a direct focus on the mechanism of *self-interaction* with which 'we meet the world' (Blumer, 1966). Burbank and Martins (2010) describe this as the mechanism that forms and guides an individual's assessment of a situation (e.g. perceived injustice), their actions (e.g. join movement), and interpretation/reflection on implications/consequences (e.g. changed relationship to authorities and 'resistance groups'). Linked to drawing from and building *tacit knowledge*, this 'internalised conversation' is an integral part of thinking and knowing and therefore key to understanding agency.

6.5.2 Complementing Symbolic Interactionism with practice-based perspectives

With a focus on practice, practice-based perspectives provide an additional insight into the relationship between objects, knowledge, practice, social groups, and context, thus complementing SI. Practice-based perspectives premise that knowledge "does not exist independently of social relations and social practices but is embedded in social interaction and situated in local practices" (Cook & Brown, 1999 in Swan et al., 2007). This provides a lens through which to understand knowledge and *knowing*, as discussed in section 2.6 (p.48), 'practice-based perspectives on knowledge'; it is a way to understand processes such as shifts in power and knowledge production/sharing as well as the associated changes in practice and identity that are part of the process.

Practice-based perspectives are significant in light of emergent phenomena because of their emphasis on four main premises: a) practice is seen as action informed by meaning; b) special attention is given to 'frames' and the use of frames to negotiate meanings around objects; c) emphasis on *boundary objects* and conceptualisation of knowledge as a boundary object; and d) *boundary objects* as both enabling and hindering practice. These are briefly defined and described below.

Practice-based perspectives highlight *practice as action informed by meaning* from a particular group context(s); it is not merely about 'doing', but about being a recognised meaning to a given group. Linking to SST, an SI/practice-based approach highlights a focus on the ways in which different actors engage in different 'thought worlds' (Dougherty, 2013) or 'frames' (Bijker et al., 2012) through which they negotiate meanings around particular objects. The creation of frames of reference, or 'technological frames', structure the interaction of members of a social group (to varying degrees) to for example, 'stabilise an artefact' (Bijker et al., 2012) or 'sediment' a practice (e.g. through the creation of an 'open science hardware manifesto' http://openhardware.science/gosh-manifesto/).

Frames are based on contextualised narratives, assumptions, and values – including them in an analysis reveals, in line with Snow (2001) discussed above, how they provide standards or build norms (sedimentation or even colonisation) and how they are used to evaluate practices, actions, and actors – for better or for worse. This analysis allows for a conceptualisation of objects as being both a medium for, as well as an outcome of complex social interactions (Prasad, 1993).

Furthermore, because SI stresses the recognition of the social constraints posed by other contexts (e.g. institutional, political, etc.) in which such negotiations are embedded (Swan et al., 2007), they place a strong focus on *boundary objects*. These refer to "artefacts, documents, terms, concepts, and other forms of reification around which communities of practice can organise their interconnections" (Wenger,1998, p.107 in Swan et al., 2007) thus, they create common ground to communicate, share knowledge, or engage in joint action (Bechky, 2003).

Linked to this, practice-based perspectives also highlight the paradoxical nature of knowledge, giving consideration to both the *enabling* as well as the *hindering* effects of knowledge production and sharing. In looking at innovation processes Swan et al. (2007) found that specialised knowledge promotes innovation (building organisational memory and

capacity) while at the same time posing barriers and divisions of practice (for newcomers and in sharing with other communities/organisations). Looking more deeply at knowledge, this perspective differentiates between knowledge acquired individually as *craft elements of practice* and those acquired collectively as *acceptable practice* (even partially) that is negotiated amongst a group or a community (Cook & Brown, 1999 in Swan et al., 2007). In the latter, a practice-based perspective can reveal the role of objects in the negotiations leading to 'acceptable practice', i.e. in reinforcing boundaries or shifting power relations. For example, objects can create (or embody) an evaluative frame of reference or aid in negotiating practices across boundaries (e.g. meanings around a map or a pollution level scale). This analysis stresses the importance of looking at both the objects' instrumental effect as well as their symbolic aspects. It helps to shed light on processes of engagement and how knowledge is translated and transformed.

Contemporary symbolic interactionists Swan et al. (2007) explain the value of an SI/practice-based approach in understanding innovation settings. It is where practice is contested through shifts in distribution of knowledge and power across specialist domains (Christensen et al., 2000; Henderson, 1991) arising from resistance and enthusiasm in the development and use of innovations (Martin, 2004, in Swan, 2007). Swan et al. (2007) argue:

> Alternative perspectives on objects – such as Actor Network Theory (Latour, 1987) – could, of course, be used to shed further light on, for example, the political process involved in innovation (Garrety and Badham, 2000). However, symbolic interactionist and practice-based perspectives emphasize precisely, and quite explicitly, the kinds of multiple perspectives, ambiguous interpretations and diverse practices commonly encountered in radical, interactive innovation settings. Whereas ANT tends to presume a central, more powerful actor within network configurations and to 'fix' (temporarily) objects in their identity (as 'actants'), symbolic interactionist and practice-based perspectives stress instead the inherent ambiguity of social situations, including ambivalence around the meanings (or multiple meanings) of objects, roles and identities (p.25-26).

In this way, the significance of this approach is in that it provides a useful lens through which to analyse the role of objects – whether they be specialised knowledge or technological artefacts - because it highlights the complexity of interactions and the inherent ambiguity of objects in the political struggle amongst actors to defend their interests and claims to knowledge, which they achieve by manipulating the meaning of objects (Weick, 1979; Lamertz et al, 2003 in Swan, 2007).

6.5.3 Generating and testing theory: method for data analysis in Symbolic Interactionism

Proponents of SI defend against the third critique of broadness in data analysis positing it as a framework that can support many specific theories. In fact, Grounded Theory emerged from SI as an important qualitative tradition addressing this critique (Williams, 2008). Grounded Theory, described in more detail below in section 6.7 (p.135), is a particular style of qualitative data analysis especially designed for *generating and testing theory* (Strauss, 1987). Developed by Barney Glaser and Anselm Strauss in 1967 as a more robust approach to Blumer's exploration and inspection in SI, Grounded Theory moves beyond merely developing sensitising concepts to generating inductively derived meso or macro-level theories of the social world (Williams, 2008). Its roots in SI are evident in Strauss' coding paradigm used in data analysis, which focuses on the conditions, consequences, interactions, and strategies/tactics of the phenomena under study[16]. Strauss' intent with his approach to Grounded Theory was to create theoretically informed interpretations of collected data efficiently and effectively (Strauss, 1987), which was lacking at the time. One of the shortcomings of Grounded Theory, as identified by Kelle (2005), is that often the research produced is too focused on micro-sociology. To address this, my research design is guided by principles of SST and other theoretical underpinnings from the previous chapters. It also makes use of data triangulation to form a complete whole, capturing different dimensions of the same phenomenon (Kulkarni, 2014) through three case studies and verification through focus groups.

6.6 The significance of a constructivist-interactionist theoretical tradition

The significance of SST and SI for the purpose guiding the study of practices of DIY enquiry is multi-fold. In addition, when the SST-SI synergy is combined with the elements from the structural perspective that underpin the theoretical framework, the micro-, meso-, and macro-levels of analysis more strongly complement each other.

[16] Which Bijker and Pinch (2011) borrow in their analysis for SST (Table 3.1).

A focus on the influence of symbolism and on how shared meaning shapes interactions between actors (including artefacts) sheds light on what is most important to the people under study (Patton, 2002). Linked to this, and based on Snow's (2001) principles, these traditions can guide research in three main ways: identifying processes of symbolisation, how these become 'sedimented' to form frames (technical and for practices of knowledge production), and if/how/why frames become altered or disrupted. Furthermore, SST and SI can help focusing in on what roles certain actions or particular interactions play in giving rise to symbols and symbolic understandings (e.g. tools, techniques, practices of DIY enquiry) and the potentiality these might have for agency. In addition, an approach informed by SST, SI and a practice-based perspective illuminates the relationship between artefacts, knowledge, practices, social groups and social context with a focus on the boundaries that create opportunities and barriers to interaction and the sharing of knowledge. Table 6.2 outlines the general assumptions and perspectives in SST and SI and their significance for this study.

This new conceptual mix of orientations extends insights into the meaning making, reflection, and action at the *micro-level* and provide a lens to analyse *macro-level* structures, generalisations, and attitudes internalised at the social level. These further shed light on the *meso- level* negotiations and mediations by groups and institutions which define strategic process seeking/countering change. Hence, this tool for analysis of DIY enquiry brings together the elements of *knowledge production* (Certomà & Pimbert's (2013) definition of knowledge and practice-based perspectives); *technology* (Misa's (1992) levels of analysis and De Certeau's strategic and tactical standpoints); and *engagement* (Friedmann's (1987) model linking knowledge to action and Haklay's (2013b) hacking hierarchy) to understand the factors influencing DIY enquiry in the micro-macro interactions of the system-lifeworld.

Table 6.2 Significance of ontological and epistemological assumptions of SST and SI for the study of the possibility of people engaging in DIY enquiry

Assumptions/principles of SST & SI	Significance for study of practices of DIY enquiry
People act based on their interpretation of objects (artefacts, gestures, utterances) in terms of symbolic and instrumental meanings; objects are social constructs	Attention to meanings and interpretations of objects and the roles they play symbolically and instrumentally Considerations for 'reflective capacity' & implications
Social phenomena cannot be fully understood without consideration for context, including interactive context; humans construct & reproduce society, society constructs publics	Consideration for the interactions between the individual and sociocultural context (actual, virtual, or imagined) – that is, between objects, knowledge, practices, social groups & social contexts Attention to interactions between self, reference groups, artefacts & construction of frames through socially derived interpretation, & self-reflection
Symbolisation or 'creation of frames of reference' is understood in terms of processes (actions and practices), their sedimentation, and their disruption as well as well as the opportunities and barriers they give rise to	Consideration for 'framings' (as structures, norms, expectations, etc.) and how they become 'sedimented', if/how/why they become altered or disrupted, and what roles certain actions or practices play in these processes
Technological frames structure interaction of social group across time & space; actors have different degrees of inclusion in frames & all actors are members of more than one frame	Considerations for issues of access / inclusion into frame (ability to modify); how frames influence interactions, culture, development of new artefacts Consideration for how technological frame shapes / is shaped by hegemonic ideologies (sedimentation) (e.g. how some groups do not recognise other forms of knowing or other frames)
Society is seen as interaction occurring between individuals, groups, object, as well as internal (inner) action	Focus on interpersonal as well as intrapersonal actions; study of actions at the individual level and in relation to larger societal structures
Human beings exercise agency & are not passive victims; they have the capacity to adapt, construct, share, resist, modify, or reject various aspects of the social world	Attention to role of social constructs in (re)creating /change/rejection of ideas, objects, & practices; what people do with agency & how they gain it
Reality is conceptualised in terms of potentiality because of its complexity; the world is comprised of many interpretations by various individuals and groups (simultaneously) in different contexts	Empirical study of actions and practices to gain contextualised understanding of various social constructs in the social phenomenon of DIY enquiry; use of Grounded Theory

6.7 Theoretical tradition: Grounded theory

As mentioned above, my approach to qualitative data analysis is based on Strauss' (1987) approach to Grounded Theory. The foundational question in Grounded Theory is "what theory emerges from systematic comparative analysis and is grounded in fieldwork so as to explain what has been and is observed?" (Patton, 2002, p. 125). It is termed Grounded Theory because it has an "emphasis on the generation of *theory* and the data on which that theory is *grounded*" (Strauss & Corbin, 1998, p. 22). For Strauss and Corbin theory denotes

> a set of well-developed categories that are systematically interrelated through statements of relationship to form a theoretical framework that explains some relevant phenomenon. The statements of relationship explain who, what, when, where, why, how, and with what consequences an event occurs. Once concepts are related through statements of relationship into an explanatory theoretical framework, the research findings move beyond conceptual ordering to theory. […] A theory is usually more than a set of findings; it offers an explanation about phenomena (1998, p. 22).

The assumption in Grounded Theory is that the theory is concealed in the data and that it can be discovered through the method of coding and memoing. Coding is a constant comparison and categorising of emergent themes. Memoing is linking relationships of the categories that emerge in the coding.

6.7.1 Generating theory

Theories require first, that they be conceived (induction), then elaborated (deduction), then checked (verification). Strauss states that "many people mistakenly refer to Grounded Theory as "inductive theory" [...] but [...] all three aspects of enquiry - induction, deduction, and verification - are essential" (p.12). Briefly explained, *induction* involves "actions that lead to discovery of an hypothesis" (p.11), that is, continuous questions being asked of the data and provisional answers given to those questions (hypothesising). These questions stem from constant comparison of coding categories and memos emerging form new and existing data. *Deduction* means "drawing implications from hypotheses or larger systems of them for the purpose of verification" (p.12). *Verification* means that the "provisional character of the linkages – of answers and hypotheses concerning them – gets checked during the succeeding phases of enquiry, with new data and new coding" (p.17). Verification here requires having

"knowledge about sites, events, actions, actors as well as procedures and techniques" (p.12). This is gained from the data collection strategy (site visits, participant observation, and workshop delivery) but also draws from personal experience, training, and study (background and research preferences). Verification in this research also involves triangulation as a way of checking the inferences drawn. It involved examining assertions and claims from more than one vantage point. In this research it involved the use of multiple theoretical perspectives (section 6.2, p.121), multiple data sources (which is presented in the case study backgrounds) and multiple data collection methods (Chapter 7, p.144). The analysis strategy for Grounded Theory is presented in section 7.5, p.162.

6.8 Methodological design strategy: Multiple case studies

In this section I describe the design strategy of this research, which is based on the case study approach. I describe the typology used to frame the design of the case studies, considerations on 'forging' theory from cases, and the purpose of purposeful sampling for theory-building. I then outline the strategy for site selection and present briefly the context, history, design frame, rationale for selection and sources of evidence for each case study.

6.8.1 Rationale: Why use a case study approach?

The purpose of the methodological design is to select an approach that will 'get the job done' and answer the research questions. As I discuss in more detail below, research aimed at theory-building is particularly suited to answer *what*, *how*, and *why* questions in unexplored research areas (Edmondson & McManus, 2007). A case study approach was selected because it is well suited for a subject that is being encountered for the first time or it is being investigated in a fundamentally new way (Gerring, 2007, p. 40). However, as Thomas (2011) notes, there is limited literature giving guidance on structure and organisation of a case study, what exists focuses mainly on its 'generalising power'. Responding to this Thomas (2011) offers a framing structure and typology for case study design, which I use in this research. It provides a means for assessing what a case study is trying to do and how it proceeds to do that; it gives guidance on the *object* and *subject* of the case as well as the framing of the case's purpose, the approach (or stance), and the process undertaken. It can be used across disciplines and traditions because strong commonalities exist across them in their use of the

case study: they have "a commitment to studying the complexity that is involved in real situations" (Simons, 2009 in Thomas, 2011). Thomas' (2011) typology is illustrated in Figure 6.1. The summary of the case study approach design frame based on this typology is outlined in Table 6.4 and the framing of each case in this study is presented in the background chapters of each case study.

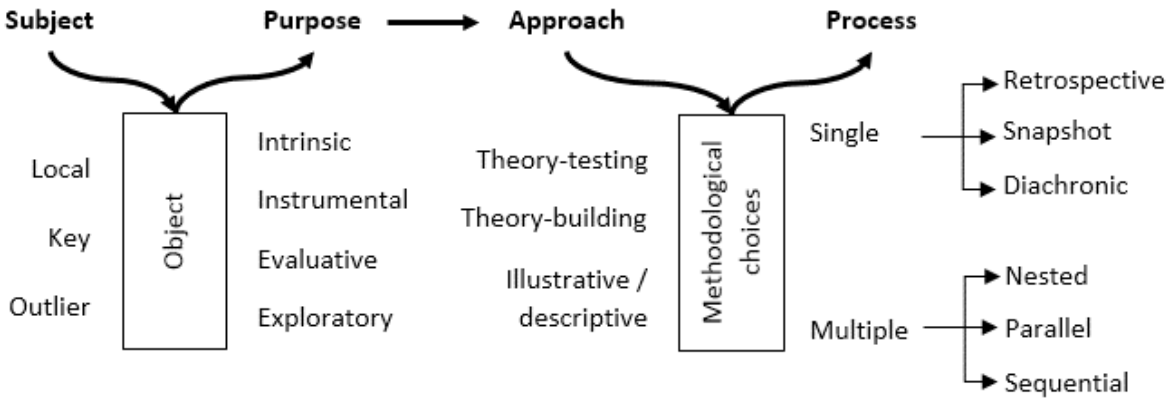


Figure 6.1. Typology of the case study: the process research design (Thomas, 2011).

For Thomas (2011), a study can only constitute research if there is something to be explained (which he calls the *object* of the case) and something potentially to offer explanation[17] (the analysis of the circumstances of a *subject*). That is, to generate theory, a study needs a characteristic unit – the *subject*, and a means of interpreting it or placing it into context – the *object* (Weiviorka, 1992, in Thomas, 2011). It is the distinction between the subject and the object in a case study that is characteristic of all social enquiry. In Thomas' (2011) typology, a case study comprises two elements:

1) a *practical, historical unity* – called the *subject* of the case study, and
2) an *analytical or theoretical frame* – called the *object* of the study

[17] Some make the distinction between the *explanandum*, the thing to be explained, and the *explanans*, the thing doing the explaining.

Based on this distinction, Thomas (ibid) defines case studies as:

> [A]nalyses of persons, events, decisions, periods, projects, policies, institutions, or other systems that are studied *holistically* by one or more methods. The case that is the subject of the enquiry will be an instance of the class of phenomena that provides an analytical frame - an object - within which the study is conducted and which the case illuminates and explicates [emphasis added] (Thomas, 2011, p.513).

6.8.2 Identifying the object and the subject of a case study

How is *the subject* identified? The selection of a subject rests on the dynamic of the relation between the subject and the object: what is there to be explained and how will it be explained. According to Thomas (2011), the subject will be selected because it is an interesting or unusual or revealing example through which the defining characteristics of the object can be determined. He defines three paths to identifying a subject: *local*, selected because of familiarity with the case (through local knowledge); *key*, selected because it is a crucial case; or *outlier*, selected for its difference. In this research the subjects for the cases in this research were selected as either local or key representations of DIY enquiry.

How is *the object* identified? The development of the object of the study is at the heart of the study. Metaphorically, the object can be thought of as the process by which change in a phenomenon is effected and the subject is "the prism through which facts and concepts, reality and hypotheses about this change [are] refracted, viewed and studied" (Thomas, 2011, p.515).

The object need not be defined at the outset. In Grounded Theory it emerges as the enquiry progresses through iterative analysis in cycles of induction, deduction, and verification, as explained above[18]. However, Thomas (2011) warns that this guiding notion is not to be confused with the *subject*. In this research, the theoretical framework and the research questions symbolise the *object* (what do people do with practices of DIY enquiry, what do these practices do to them, and what factors contribute to that?) across the representations of DIY enquiry in cases studies (*subject*).

[18] Grounded Theory-based research does not start with a 'blank slate'; it is based on an initial notion guiding it and is developed from personal experience, interests, and literature review.

6.8.3 Case study selection: the purpose, approach, and process of a case study

The purpose of a case study is intimately connected to the object of the study: the understanding or explanation that is required is related to the reason for doing the study, that is, *the purpose* (Thomas, 2011). Thomas identifies four reasons – or the purpose – for doing a study: intrinsic (Baxter & Jack, 2008; Ghesquière et al., 2004), instrumental (Stake, 1995), evaluative (Merriam, 1988), and exploratory (Eckstein, 1975; Yin, 2009). These are described in Table 6.3.

Table 6.3. Typology of case study purpose

Case study purpose	Definition / use
Intrinsic	An intrinsic case is studied because of its specificity (Ghesquière et al., 2004); that is, in all its particularity and ordinariness, the case itself is of interest and not necessarily to generalise and build theory (Baxter & Jack, 2008).
Instrumental	The purpose of the instrumental case is "to amass knowledge and to construct a theory that goes further than the specific case that is studied" (Ghesquière, Maes, & Vandenberghe, 2004, p. 172). Stake (1995) considers this to be a case of secondary interest playing a supportive role, facilitating our understanding of something else.
Evaluative	Evaluative cases "involve description, explanation, and judgement [of an intervention]" (Merriam, 1988). These cases are particularly useful to explore situations in which an intervention being evaluated has a variety of different outcomes (Yin, 1984).
Exploratory	Exploratory cases study situations in which the intervention being investigated or evaluated has no clear, single set of outcomes (Yin, 2009). Eckstein (1975) employs the terms 'heuristic' to define exploratory studies.

Cases can have a combination of purposes. In this research, cases have instrumental, intrinsic and exploratory purpose. As I shall illustrate in the next chapter, the pilot case studies have instrumental purpose in amassing knowledge about barriers and opportunities to engagement in citizen science in general and community enquiry specifically; the three main case studies have an intrinsic purpose in being cases of DIY enquiry in specific contexts; and the purpose of the three main cases is to explore the phenomenon of DIY enquiry.

The approach of a case study (see Fig. 6.1) is the stance taken about the object or the analytical/theoretical frame. It can be theoretical or illustrative. The theoretical stance can be either *theory-testing*, set clearly at the outset, or *theory-building*, developed throughout the study (Bassey, 1999, in Thomas, 2011). In this research the approach for the pilot cases is illustrative. In the main case studies I take a theory-building approach following Grounded Theory.

The methodological choices for data collection/analysis are vast, ranging from interpretive and ethnographic to experimental or a combination of mixed methods. In this research I take a mixed methods approach following the methodological orientations of SST and SI informed by practice-based perspectives and the methodological tradition (Table 6.4).

The process is determined by whether there will be a comparative element in the cases. This determines if the study will be *single* or *multiple*. In selecting a case, many decisions about process arise: "Can the research question be addressed by a single focus on one person or situation, or would a comparison be better? Is there a time element that will be addressed by looking at a sequence of events or is it better to examine one tightly defined period in time? Would it be helpful to extract a number of nested elements from the main focus and to examine these in detail?" (Thomas, 2011, p.518).

Single studies with no element of comparison can take three forms: *Retrospective*, *snapshot*, or *diachronic* (looking at change over time with data capture occurring at different points and the point of interest being the changes occurring between those data collection points) (Thomas, 2011, p.517).

Multiple studies, which is the approach selected in this research, raise considerations about how cases will be used for comparison; these also take three forms: *nested*, *parallel*, and *sequential*. The *nested* case comprises comparison of 'elements' within a case. Nested type of comparison is different from a 'straightforward' multiple study (comparison within different examples) in that the nested case "gains its integrity, its wholeness, from the wider case", that is, "[t]he elements are nested only in the sense that they form an integral part of a broader picture" (Thomas, 2011, p.517). For example, a three-year case can have within it layered and nested elements with various units of analysis from individual experiences, yearly gatherings, reports, email threads, etc. (Patton, 299). The *parallel* study comprises studies occurring simultaneously and being studied concurrently. The *sequential* study refers to cases happening

consecutively assuming that what happens in one case or "intervening period will in some way affect the next" (ibid). The cases in this research are both nested and parallel.

The decisions taken in designing a study occur simultaneously and iteratively particularly in relation to the subject, object, and approach/stance of the cases. The two-dimensional representation of the typology, which flattens these decisions, can be misleading. Nevertheless, the typology provides a useful visualisation to more clearly follow and understand the way theory is 'forged' from the cases. The design frame for the cases in this research is summarised in Table 6.4 below.

Table 6.4: Design frame for case study approach in the study of DIY enquiry

Design frame element…	…in the study of DIY enquiry
Practical, historical unity" or *subject*	Local / key representations of DIY enquiry
Analytical or theoretical frame or *object*	Theoretical framework & research questions: "What do people do with practices of DIY enquiry, what do these practices do to them, and what factors contribute to that?"
Purpose	Instrumental, intrinsic and exploratory
Approach	Illustrative & theory-building
Methodological choice	Multi-method
Process	Nested & parallel

6.8.4 Forging theory from cases

In this investigation, I used a set of linked case studies to develop a thesis about how practices of DIY enquiry develop: what people do with these practices and what these practices do to them as well as what factors facilitate or hinder their possibility. I looked at a range of DIY practices, individual and collective, where enquiry, tools, and techniques were developed and used. Here I describe the process and consideration of how the explanations put forth in this thesis were developed.

Case studies emphasise the rich, real-world context in which phenomena occur. Forging theory from cases requires various steps and considerations: a) justification for theory-building (as opposed to theory-testing); b) iterative analysis between data, emergent theory, and literature; and c) measures of research quality. I describe these next.

Adopting a theory-building approach requires justification. That is, justifying why a *theory-building* approach is better suited than a *theory-testing* approach.

This justification for an approach is reflected in the nature of the research questions of the study. Theory-building research is particularly suited to answer *what*, *how*, and *why* questions in unexplored research areas (Edmondson & McManus, 2007). In contrast, theory-testing aims at answering *how often* and *how many*. In the Grounded Theory approach, as research progresses and more data or evidence is gathered, the inquirer needs to constantly and iteratively ask, 'what is this a case of', 'what is this representative of', and 'what is this pointing to?' Answers to these questions build potential explanations or theories (Strauss, 1987; G. Thomas, 2011). The process of building theory from case studies depends on iterative analysis between case data, the theory that emerges, and the literature. It requires the consideration for "the elaboration of theory [as] a means to an end, with that end being explanation. However, theory is not an end in itself"; it is about discovering and testing tools of explanation (Thomas, 2011, p.515)

Multiple case studies were used in this research because they typically provide a stronger base for theory-building: the theoretical propositions produced are more deeply grounded in varied empirical evidence (Eisenhardt & Graebner, 2007; Yin, 2009). Multiple case studies also enable comparisons that clarify whether an emergent finding is simply idiosyncratic to a single case or consistently found in several cases (Eisenhardt, 1991). While it is argued that theory from multiple cases is more robust, the resulting theory is also more parsimonious as it only retains the relationships that are comparable across most or all of the cases[19] (Eisenhardt & Graebner, 2007). In this research, the need for multiple cases was justified from the fact that DIY enquiry is an innate process, yet extant literature largely takes for granted the process of enquiry – how it begins and what hinders/nurtures it. In addition, each case study has its own Grounded Theory, making transparent what and how it was done. As we saw in the literature review, there is no existing theory that offers an answer to the research problem. Different aspects of various theories stemming from a range of disciplines can be put together to attempt an explanation. However, the phenomenon of DIY enquiry as a whole cannot be adequately explained in this way. For these reasons, the stance of this research is to develop theory – not to test it.

[19] In contrast, single cases can enable the creation of more complicated theories because theory can fit exactly into the many details of a particular case (Eisenhardt, 2007).

Research quality is judged by the transparency of the process, including theory building. For Eisenhardt and Graebner (2007) this means making this process clear:

> [E]ngaging in systematic data collection and theory development processes that are reported with transparent description, particularly regarding how the theory was inducted from the data. […] The key here is to convey the rigor, creativity, and open-mindedness of the research processes while sidestepping confusion and philosophical pitfalls (p.30).

The key to good theory building according to Eisenhardt and Graebner (2007) is to make sure that the theory has explored the nuances and alternative interpretations of the available evidence as fully as possible. We now move to the 'methodological practice' in the next chapter, which covers the tools and procedures for data collection and analysis.

7. Methodological practice

The previous chapter covered the methodological theory, outlining the methodological orientation (bringing together the perspective from the Social Studies of Technology and Symbolic Interactionism, complemented by practice-based perspectives), methodological tradition (Grounded Theory), and design strategy of this research (multiple case studies). This chapter covers how the theory is applied in 'methodological practice'. I describe the site selection, give case study overviews, present research questions, data collection and fieldwork, data analysis procedures, and research quality.

7.1 Methodological design strategy in practice: Site selection

The case studies were selected on the basis of their suitability to answer the research questions and their viability. The viability of the cases is based on the unit of analysis, the background, setting, key informants and initial elements of interest. Following from the literature review and the micro-macro approach from the methodological orientation, the case studies selected focused on units of analysis at both the individual and group/community levels, giving a more comprehensive understanding of practices in DIY enquiry.

The cases were also viable because elements of research interest were present in all the case studies, there was access to key informants, information/documentation was publicly available, and sites/community were accessible. The latter cannot be taken for granted as the relationships with the communities were built on trust: there was collaborative exchange through iterative discussion of research findings, which intended to benefit the development of the community and avoid extractive research. Table 7.1 summarises the criteria for case study selection.

Table 7.1: Criteria for case study site selection

Case study dimension	Criteria
Unit of analysis	community, individuals, people sharing a culture, common experience - participants, members, etc.
Case's background	Instances of DIY practices; individual/community engagement in DIY; development and/or use of DIY artefacts, tools, & techniques; community engaged and growing (in experiences or dynamic).
Setting	community of practice; online presence, face-to-face gatherings
Key case informants	community members across a spectrum of engagement in DIY practices; historical and procedural documentation - wiki (as research notes); annual reports, etc.
Initial elements of interest	Contextualised and situated engagement processes and interactions; engagement with DIY tools/techniques; perceived barriers/opportunities
Other criteria	Site accessible and open to newcomers; English language; substantial information and documentation open and accessible

7.2 The case studies

As mentioned in the previous chapter, the pilot cases provided an opportunity to scout out my research interests, initial topics of research, and broad theoretical categories (see section 1.3, p.21). My experiences from direct observation in these helped me to identify gaps and also shaped the initial framing of the research questions by helping me to raise initial *generative questions* (section 7.5, p.162).

7.2.1 Pilot case: Mildmay community centre

The first case study I engaged with in this research was with the Mildmay Community Centre (MCC). The case was selected because of the precedence of previous work in 2008-2009 on the Citizen Science for Sustainability project (SuScit). Action Research and networking activities had been designed to promote engagement and dialogue between the Engineering and Physical Sciences Research Council (EPSRC), Sustainable Urban Environment research community, professional stakeholders and practitioners, and local residents – disenfranchised groups in particular. The project was successful in identifying areas that had not been covered by the EPSRC research agenda, specifically, the social dimensions of sustainability. My intention was to reconnect with some of the people involved and build on

work that had been done at the MCC. However, there were very few of the people left who had taken part in SuScit. It seems that the project itself had not been able to create a sustainable network between researchers, practitioners, and residents. Despite this I decided to create new contacts at the MCC and carry out public engagement activities, namely, the Touch|Play|Learn interactive exhibition to showcase DIY environmental tools. The MCC case study was extremely valuable for reasons that were not anticipated.

Figure 7.1: Balloon mapping at the Touch Learn exhibition, Mildmay Community Centre, 2012 [Source: Cindy Regalado]

Contribution to research: What I learnt from my engagement with the MCC (as participant observer, through interviews, and through organising the Touch|Play|Learn activities) guided the foundations for my theoretical framework. Specifically, initial questions about what is the role of institutions in public engagement in science and technology, what needs to be in place for people to take action in addressing issues of concern to them, and could these efforts be possible and sustainable on their own? Reflections from this case study led me to begin writing the book chapter "Getting out of their way: Do-It-Yourselfers, sensing, and self-reliance" (Regalado, 2016). This case study also provided a good reminder that in some cases there are larger social structures in place acting as barriers to engagement, including issues of class and race, which are out of the researcher's control. These societal issues shape perceptions on institutions, what they represent, and the people associated with

them. These insights are represented by the upper left and upper right quadrants in the theoretical framework in Figure 5.1 (p.107) as 'symptoms of the state' and 'status of science'.

Design frame and selection rationale: This case study was local as I developed personal knowledge of the context from SuScit and by engaging directly with various community stakeholders. The case was instrumental with the purpose of gaining foundational insights into the broader themes and way of framing my research on DIY enquiry. Its purpose was also exploratory in that it helped to generate foundational questions about public engagement in science, issues of participation, and the gaps in the literature in field of Social Studies of Technology and Citizen Science. As a pilot, this case took on an illustrative/descriptive approach and it is part of multiple parallel case studies with nested elements of interest across cases. The latter is illustrated in part in the book chapter mentioned above, with the theoretical framework being applied to the Public Lab case study. Nested elements are also illustrated in the journal article "Promoting playfulness in publicly initiated scientific research: for and beyond times of crisis" (Regalado, 2015) drawing parallels between Touch|Play|Learn, playshops, and Public Lab activities. This design frame is illustrated in Figure 7.2.

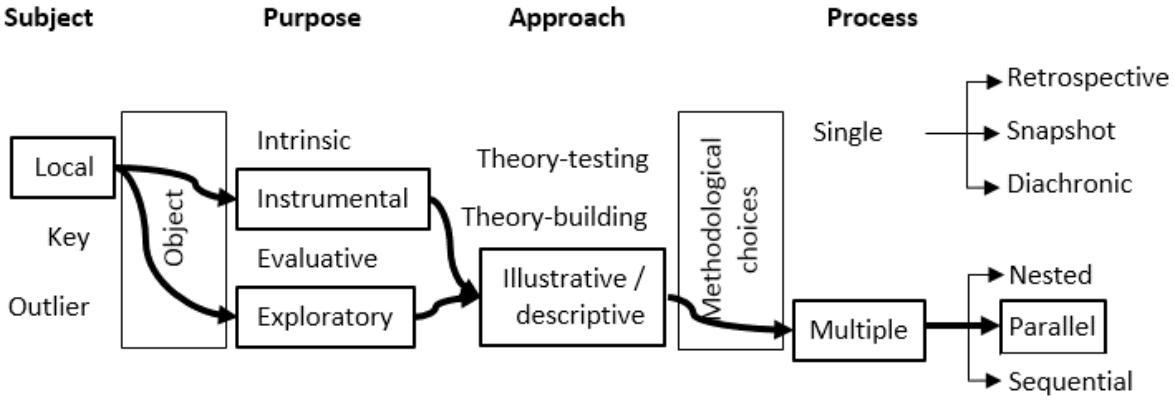


Figure 7.2. Research design for Mildmay community centre pilot case

Sources of evidence: My active engagement with the community centre for a year and a half afforded me the opportunity to collect various sources of evidence to initial frame the research and then triangulate findings in the broader context initial engagement in DIY enquiry. These sources of evidence are listed in Table 7.2.

Table 7.2: Sources of evidence for pilot case at the Mildmay Community Centre

Data type	Description	Year
Report	• Project report for Citizen Science for Sustainability	2009
Audio interviews	• Meeting with Activities Manager • Meeting with board member • Meeting with architect	2012
Reports	• Interim Report • Final Interim Report • Architectural report on history of centre & architectural development	2012
Photos/ video	• Video & photographs of public engagement project & activities "Touch|Play| Learn"	2012
Field notes	• Observations & reflections on community engagement	2012-13
Report	• Report on public engagement project & activities "Touch | Play | Learn"	2012
Field notes	• On interview with Architect • Follow up interview (6 months on)	2013

7.2.2 Pilot case: Citizen Science summit

The Citizen Science summit (CCS) took place in 2010, 2012, and 2014. With an active element of DIY practice, the event intended to bring together leading figures in citizen science to explore the process of public engagement, participation, and outreach of citizen science in all its forms and conceptions. I had my first Arduino workshop at the 2012 CCS (Figure 7.3).

Contribution to research: I interviewed summit attendees and the themes that emerged, namely, questioning where are the 'citizens' of 'citizen science', what are the tensions in the contrasting approaches to participatory engagement in scientific research, and what is the variety of motivations/justifications for employing those approaches? Interviews at a subsequent Summit in 2014 also revealed a gap in our understanding of how people come to begin their engagement in DIY practices, using tools and methods of science, specifically, what opportunities and challenges arise when people take initiative? Data to explore this further could not be obtained at the summit due to the audience and nature of the event (no continuity) but it put into perspective my experiences at the MCC and provided me with initial insights to guide *dimensionalising* of data to *theoretically sample* it (see section 7.5, p.162) in the subsequent parallel cases.

Selection rationale: This second case study presented an opportunity to engage with practitioners and scholars and discuss gaps, concepts, theories, and practices of citizen science. It helped me to raise initial questions and concepts about processes and interactions in the far end portion of the citizen science spectrum: citizen-led initiatives.

Design frame: This was a local case study consisting of three events in a thematic area of interest and interactions with several persons of whom I had (or developed) personal knowledge of their work. The purpose was instrumental with insights gained contributing to the broader framing of my research on DIY enquiry. Its purpose is also exploratory in that it helped to explore foundational questions about public engagement in science, issues of participation, and the gaps in the field. Hence, it took on an illustrative/descriptive approach; the interviews and conversations helped me 'bounce ideas' rather than provide data. This case was part of the multiple parallel case studies demonstrating nested elements across cases. The design frame is illustrated in Figure 7.3.

Figure 7.3: Arduino workshop by Tom Igoe at Citizen Cyberscience Summit 2012

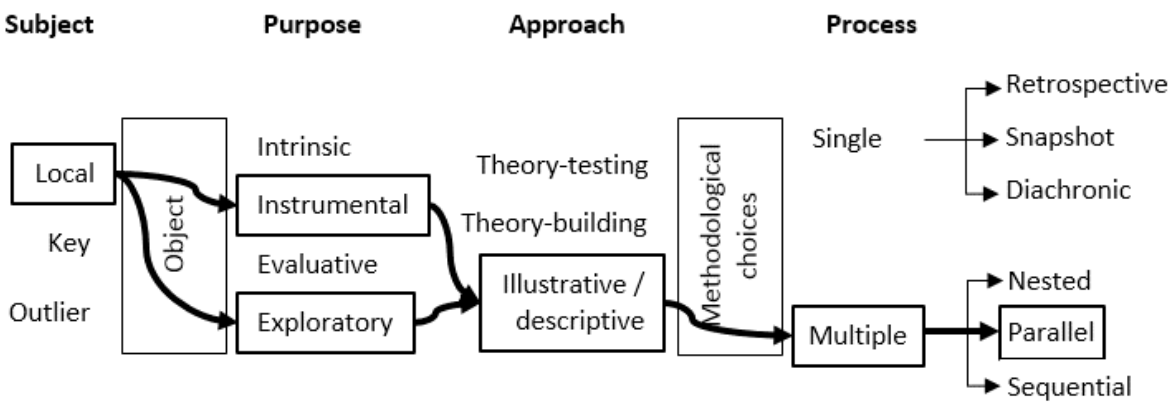


Figure 7.4: Research design for Citizen Science Summit pilot case.

Sources of evidence: My engagement in two of these events enabled me to collect audio visual sources of evidence to initially frame the research and then triangulate findings in the broader context of citizen science. These sources of evidence are listed in Table 7.3.

Table 7.3: Sources of evidence for pilot case at the Citizen Science Summits

Data type	Description	Year
Audio interviews	• Five interviews with speakers at the Citizen Science Summit on the spectrum of engagement in citizen science, requirements for engagement in citizen science, and who is missing at the summit	2012
Audio interviews	• Interview with member of the public 1 on their DIY inquiry project • Follow up interview (3 months on)	2013
Video interviews	• Six interviews with speakers at the Citizen Science Summit on the spectrum of engagement in citizen science, requirements for engagement in citizen science, and who is missing at the summit; their take on community/grassroots science	2014
Photos / video	• Video and photographs of workshop designed by a member of the public on their DIY project and delivered at the Citizen Science Summit 2014	2014
Photos / video	• Hackathon workshop & presentation by member of the public 2 on their DIY project at the Citizen Science Summit 2014	2014
Audio interviews	• Interview with member of the public 1 on their DIY inquiry project • Follow up interview (3 months on)	2014

I now turn to an overview of the main case studies in this research.

7.2.3 Main case studies: an overview

The main case studies provide the 'bulk' of the empirical data for this research on which iterative data analysis was carried out and from which *substantive* theory (section 7.5, p.162) about engagement in DIY enquiry was drawn. The cases are:

- The Public Laboratory for Open Technology and Science as a case of processes and interactions in an actual community of practice engaged in activities of socio-technical DIY, including use and development of DIY tools and techniques (Chapters 8 & 9);
- Public engagement in DIY enquiry through playshops as a case demonstrating the initial stages of engagement in DIY including barriers and opportunities to engagement in these practices through Citizens without Borders – CwoB (Chapters 10 & 11); and
- Place-based citizen initiatives of DIY enquiry, as a case of citizen-led DIY enquiry in a real-world context – the Gowanus canal in New York City (Chapters 12 & 13).

Table 7.4a summarises the methodological design strategy and basic information for the main case studies analysed in this research including unit of enquiry, mode of enquiry as fieldwork strategy, and data collection approaches. Table 7.4b presents the case studies as a timeline. It also highlights some of the main contributions that each case makes to the study of DIY enquiry. Note that these are not the only aspects of DIY enquiry that these cases shed light on but rather, the ones that they offer a unique perspective on to illustrate the different dimensions of DIY practice. The next section presents the research questions and how the methodological design strategy in each case contributes answers them.

Table 7.4a: Main case studies overview

	Community of DIY practice	DIY enquiry through playshops	Place-based citizen initiatives of DIY enquiry
Duration	4 years	3 years	3 years
Location	Louisiana, U.S.; online	London, UK	New York, U.S.
Unit of enquiry	DIY in community of practice	DIY at Individual & small group level	DIY embedded in place
Fieldwork strategy	Researcher as participant & community organiser	Researcher as facilitator & design of playshops	Researcher as observer
Data collection strategy	Participation at community events, interviews, focus group, secondary data, field notes	Workshop design, implementation, interviews, group reflection, field notes	Site visits, interviews, review of secondary data, field notes
Sheds light on…	How DIY enquiry unfolds in a community of practice: culture, values, interactions	Initial steps in engagement with DIY enquiry; barriers & opportunities for engagement at individual level & through group interactions	Standpoints on DIY; salient actions / responses by grassroots & DIYers to achieve actionable goals

Table 7.4b: Case studies overview in timeline

Case study	2012	2013	2014	2015
Pilot case: Mildmay community centre	Observation of interactions between people & with DIY tools, creation of meaning, & experiences of DIY enquiry, informal interviews			
Pilot case: Citizen Science Summit	Observation, informal interviews, reflective conversations			
Main case: Community of practice	*Researcher as participant observer*			
	Visit Public Lab Barnraising 2012	Visit Public Lab Barnraising 2013	Visit Public Lab Barnraising 2014	Visit Public Lab Barnraising 2015
DIY enquiry through playshops		*Researcher as facilitator*		
		Playshop series 1	Playshop series 2	Playshop series 3
Place-based DIY enquiry		*Researcher as observer*		
		Initial site visit	2nd site visit; interviews with resi-dents & community groups	3rd site visit; interviews with community groups & EPA

7.3 This is how it all fits together: Research questions & methodological diagram

The primary research goal for this study is to investigate what people do through practices of DIY enquiry and what these practices do to them with a specific focus on production of knowledge, the role of technologies, and the barriers and opportunities to engagement in DIY enquiry. With the considerations from the above guiding ontological orientations and the review of the literature, the specific questions put forth in this research are:

1. What do people do through practices of DIY enquiry and what do these practices do to them?
    a. What is the nature of knowledge production in DIY enquiry?
    b. What is the role of technologies in DIY enquiry?
    c. What are the barriers & opportunities to public engagement in DIY enquiry, tool & technique development, and use?
    d. Can and how can these be overcome and/or the opportunities exploited?
2. What factors contribute to the possibility of public engagement in practices of DIY enquiry including the development of tools and techniques?

Figure 7.5 illustrates how the contribution that each case makes comes together to answer these questions. This is useful as each of the main cases (Chapters 9, 11, and 13) present the analysis within the cases: the insights, themes, categories, and relationships between these that explain the situations specific to the cases. Chapter 14 is the discussion of how this case-specific analysis feeds into the macro analysis answering the research questions and comparing back to the literature reviewed on knowledge (Chapter 2), technologies (Chapter 3), and engagement (Chapter 4). Figure 7.5 shows the multi-method approach used in data collection and how each case contributes to answering the research questions. Specifically, it shows how the different methods of participant observation, facilitation, observation, and document analysis (detailed in the next section) are used to gain specific understandings of each case at the case-level but together contribute to addressing the research questions thus providing a more comprehensive understanding of DIY enquiry.

Figure 7.5: Research methodology: research questions (green) with methodological case study design (shades of pink for main cases, yellow for pilot cases), fieldwork strategy (blue), and elements of the research enquiry that facilitate the study of the phenomenon of DIY enquiry.

7.4 Data collection & fieldwork strategy: procedures and tools for data collection

All data collected in this research is qualitative. The fieldwork strategy includes in-depth enquiry through three modes of enquiry (multi-method approach) employing a range of data collection instrumentation: interviews, participant observations, careful review of documentation (online and offline), and examination of artefacts. Different types of data give different views and vantage points, and in this way, qualitative data collection provides rich case studies that capture the nuances of DIY practices at the individual, community, and place levels.

The data collection strategy consisted of several stages and iterations, following the Grounded Theory method (section 7.5, p.162). The initial step was 'scouting' the landscape of engagement in more hands-on types of citizen science (i.e. at Citizen Science Summit pilot case study) and learning, in context, what opportunities and problems arise in specific cases where people take initiative in DIY enquiry and engage with techniques and tools (i.e. at MCC pilot case study). This early fieldwork was complemented with review of relevant literature and initial data analysis. This led to the emergence of new insights, gaps, and concepts to be explored giving shape to the research questions above, and informing the data collection and analysis of the three main case studies. The final stage in the data collection strategy involved triangulation of data from the previous stage through workshops and a focus group. This process involved iterative revisions, discussions, and juxtaposing against new literature. In the next sections I detail the fieldwork strategy and the data collection instrumentation.

7.4.1 Fieldwork strategy: roles of the researcher

The overarching approach to fieldwork strategy was *direct observation*. Direct observation (as opposed to e.g. collection of secondary sources) provides a first-hand opportunity at absorbing the nuances of meaning, appreciating variations in participant's experiences, capture what happens outside formal activities and get a sense of the context and environment of a setting. Observation constitutes a field strategy that simultaneously

combines interviewing, document analysis, direct observation, and participation (Denzin, 1978). It complements other data sources because direct observation provides setting description – i.e. an account of the people who participated, the objects, and situations in the setting – as primary data, relying less on secondary accounts of the setting. Another advantage is that it affords an opportunity to observe and experience situations to which interviewees refer thereby giving the researcher the ability to contextualise and triangulate the different sources of data. Observation in this research is seen as a context for interaction among those involved in the research; it is a collaboration between the researcher and the participants (McKechnie, 2008). Finally, because of the exploratory nature of this research, direct observation during site visits focused on observing things that no one else had paid attention to or that interviewees chose to not share or describe; that is, it allowed me to move beyond the 'selective' perspectives of other data sources (such as interviews) (Patton, 2002, p.264). For example, I was able to discern the different circumstances under which DIY is discussed leading to varied attitudes towards the practice. Direct observation also enabled me to draw on personal knowledge (as reflections and introspection) during the formal interpretation stage of the analysis.

For different settings and under various circumstances (i.e. nested within a case) participation varies along a wide continuum of possibilities and it is the researcher's role to design and negotiate a degree of participation that will yield the most meaningful data about the phenomenon given the characteristics of the participants, nature of interactions, socio-political context, and goals of the research (ibid).

Role of the researcher as multi-method approach. The design of this strategy for an exploratory research takes into consideration the role and perspective of the researcher as well as the duration and focus of the fieldwork, summarised in Table 7.5. In this study my role involved full participation in settings where the focus was on understanding DIY practices of engagement activities and an onlooker role where the focus was on community initiatives in a real-world context. An insider perspective was developed over time with careful attention to reporting observations to internal and external audiences. The duration of the fieldwork was ongoing over a period of three to four years with multiple data collection and observation periods in each case study. Below I describe the specific considerations for the different aspects of the strategy.

Table 7.5: Summary of fieldwork strategy in direct observation

Role of the researcher	Multi-method: facilitator; participant observer; observer (see Table 7.6)
Perspective	Insider/outsider balance
Duration of fieldwork/observation	Ongoing cases with multiple observations of sequential activities over time, multiple site visits
Focus of fieldwork/observation	Narrow scope on DIY practices with focus on multiple predetermined and emergent guiding concepts & elements

As described in section 1.5 of the introduction (p.27), a multi-method approach is one in which two or more research methods are conducted, each carried out rigorously and complete in themselves within one project (Morse, 2003). Triangulation is then used to capture different dimensions of the same phenomenon (Kulkarni, 2014). It was used for this research because each case study has a unique unit of enquiry (Table 7.4a). It is also a good approach to conceptualise the previously unexplored depths to DIY practice in a way that reveals mechanisms of exclusion at the individual, the community, and place levels. Table 7.6 presents the three different roles undertaken for each of the main case studies.

Perspective. The methodological challenge for the insider-outsider perspective is to 'do justice' to both perspectives during and after fieldwork and to be clear with one's self one's audience how this tension is managed. Experiencing the setting as an insider accentuates the 'participant' aspect in participant observation. At the same time, the researcher remains aware of being an outsider observer. In this research, the balance came from trying to understand the setting as an insider by engaging in community activities and having extended or constant site visits, while trying to describe the case studies from an outsider's perspective to an outside audience (ibid).

Fieldwork duration. Fieldwork in the social sciences aims to "unveil the interwoven complexities and fundamental patterns of social life – actual, perceived, constructed, and analysed" and this takes a long time (Patton, 2002, p.274). However, in practice, fieldwork should last long enough to "get the job done" – i.e. to answer the research questions and fulfil the purpose of the study (ibid). The case studies in this research were studied in parallel and the nested nature of the cases resulted in varying lengths of observation/participation required: from single community events or workshops, to multiple 2-week-long site visits and iterated activities.

Table 7.6: Multi-method approach in role of researcher

Role of researcher	Characteristics of role	Benefits of role	Drawbacks of role
Participant observer as 'complete member' – in community of practice	Researcher is overt & is active member of group & participates in the full range of activities/social relations accessible in the group being studied	Can study social processes over time; insider understanding & trust; generates rich descriptions; powerful when combined with e.g. interviewing; unobtrusive, therefore able to generate trustworthy data	researcher over-engaged & too familiar with research participants / setting; loss of capacity to note nuance in inter-actions; adoption of values, customs, practices of group & therefore uncritical reporting
Researcher as facilitator – in playshop design & delivery	Is non-directive, non-coercive, & non-evaluative; suggests concepts/tools that might be useful to participants; creates rough agenda & promotes reflection; involves constant reflection, listening, observing	Enables focusing interaction of participants toward open exploratory activities & discussions around topics of interest; enables managing setting to create safe, inviting environments; enables active participation	Amount of time & effort required to set up & run workshops; time/place & other logistics means not all who might want to participate is able to; demands constant attention
Researcher as observer – in place-based citizen-led initiatives	Identified as 'researcher' in field; watchful, distant role & relationship with members of community groups during observations	Complements participant's accounts from interviews; enables discovery of unanticipated phenomena	Not all cognitive processes can be directly observed; can't always be at the right time/place; time/resource consuming; observation subject to researcher bias/filter

Fieldwork focus. The focus of this research is narrowed in on understanding DIY practices – the *object* of the cases, i.e. the theoretical/analytical frame. Hence, following Grounded Theory, and while bound to the focus of DIY practices, the iterative data collection and analysis of this research was emergent, refracting elements of:

- Processes by which people enter DIY;
- processes of socialisation (interaction and meaning-making);
- activities surrounding DIY practices (formal, informal, unplanned); and

- context (including physical environment) in which these practices, people, and objects are situated.

7.4.2 Instrumentation and sources of data

As an exploratory investigation based on multiple case studies and a multi-method approach to fieldwork strategy, data collection required the gathering of multiple sources of information providing multi-perspectival understanding and triangulation: "no single source of information can be trusted to provide a comprehensive perspective" on the phenomenon under study (Patton, 2002, p.306). Hence, a combination of interviews, observations, document and artefact analysis, group discussions and workshops, enabled the researcher to validate and cross-reference research findings.

Multiple sources of data also require multiple methods for data collection. These are shown in Figure 7.5 (p.154). As mentioned above, the data collection procedures in this study follow from a constructivist-interactionist socio-technical tradition based on a Grounded Theory approach of iteration, emergence and constant comparison, and are adapted to a case study design frame (presented in the background chapters for each case).

During the past four years I have spent a total of six months at the different case study sites to personally experience the settings and interact with the participants. Immersion through participant observation, facilitation, and site visits afforded me direct personal contact with the subject matter so as to understand the context of each site (Patton, 2002). The data collected during fieldwork included recordings of in-depth, open-ended interviews; documents and reports; online discussions and articles; audio-visual material (videos and photographs), and direct observation recorded in my field log. These are explained below in more detail. The sources of evidence for each of the main cases is presented in their corresponding background chapters. In-field verification was done through focus groups for the Public Lab and DIY workshops cases.

Interviews. These used open-ended questions that yielded in-depth responses about the informants' experiences, perceptions, feelings and knowledge on the subject of DIY practices. Two interview approaches were used in this research: informal conversation interview and the interview guide (Appendix A.1-A.3). The main characteristics of interviews are listed in Table 7.7.

Table 7.7: Interview approaches: informal and interview guide

Informal conversation interview	• Relies on the natural flow of an interaction and is part of the ongoing participant observation fieldwork; • Also emerges from observations; allows exploration and understanding of current circumstances as well as identification of patterns, gaps or unknowns;
The interview guide approach	• Is based on concepts and issues to be explored; • The guide serves as a checklist during the interview to ensure all relevant topics of the research are covered as much as possible; • Guide checklist: used across the interviewees to ensure comparability; used at several stages in the research and was iteratively adapted and narrowed into specific topics/concept to confirm and disconfirm patterns and hypothesis that emerged; • Allows flexibility and keeps the interview conversational and situational – enabled for natural responses to emerge

The themes for the interview guides for the main case studies are presented below in Table 7.8.

Table 7.8: Themes for interview guides used in case studies

Case study	Interview guide themes
Community of DIY practice	Background and involvement; nature and character of community; commonalities between people in the community; concerns/topics of interest (personal and social level); interactions between community members & tools/techniques used; barriers & opportunities to engagement
Public engagement in DIY enquiry through playshops	Conditions for and outcomes of a playshop; personal and societal dimensions of a playshop; concerns/topics of interest (personal and social level); Interactions between people and different physical media used; playshop method and facilitation; barriers & opportunities to engagement
Place-based citizen initiatives of DIY enquiry	Background and involvement; nature and character of place; concerns/topics of interest (personal and social level); interactions between community organisations & state actors & tools/techniques used; barriers & opportunities to engagement

Observations. Observations across cases yield detailed, longitudinal, and thick description of the case studies. The framework for observation included the 'fieldwork focus' elements outlined above (processes, activities, and context). It also focused on patterns of 'what does not happen'. If, as Patton (2002) notes, the researcher "reported only what occurred, a

question might be left in the mind of the reader about whether the other activities had occurred but had simply not been observed" (p.295). Concepts and elements used to observe what does not occur are based on literature, documentation, research discussions, and personal experience, but they also emerge as patterns from iterative analysis as 'gaps' or unknowns. Exploratory research tends to open up more questions and areas for future research. Observations were recorded as field logs both digital and handwritten. The framework for observation also includes 'observing oneself'. In qualitative enquiry this reflexivity emphasises the importance of "self-awareness, political/cultural consciousness, and ownership of one's own perspective" and reminds the researcher to be attentive to and conscious of cultural, political, social, linguistic, and ideological origins of her perspective and voice as well as – and at times in contrast to – the perspectives and voices of those she observes and interacts with during research (Patton, 2002, p.299). My field logs also document observations on my personal journey of engagement with DIY.

Documentation and artefacts. Written materials analysed included publications, reports, articles and blog posts about the different projects and activities undertaken by the case study groups. The examination of documents provides pathways and prompts for initial and further enquiry. Some documents can provide information that is not available from interviewees and they provide historical and background information for the case study context. For confidentiality issues, only records that were publicly available were included in this research. The interaction with physical objects was essential for the study of DIY; fieldwork included my personal engagement with, development, and use of DIY tools as well as observation of the various interactions with and conceptualisation of (including perceptions and attitudes towards) the artefacts by the case study groups/communities.

7.4.3 Guiding concepts from observation

Observers do not enter the field with a 'blank slate'. While inductive enquiry emphasises the importance of being open to whatever one can learn, some way of organising the complexity of experience is necessary (Patton, 2002). The initial guiding concepts used in data collection and initial analysis through Grounded Theory (section 7.5 p.162) were developed from the pilot cases and first two main cases (community of DIY practice and DIY enquiry through playshops) and initial review of the literature. Through literature review, personal experience,

and deeper analysis, especially of the third main case study (Gowanus Canal) refined guiding concepts emerged (Table 7.9):

Table 7.9: Guiding concepts for the study of DIY enquiry

Initial guiding concepts (from pilot cases, 1st & 2nd main cases, and initial literature review)	• Processes of engagement in DIY • Societal factors influencing engagement in DIY • Personal/group level factors influencing engagement in DIY • Barriers and opportunities to engagement in DIY
Emergent guiding concepts (from 3rd case study & additional literature) but also continued from 1st and 2nd main cases	• Production of knowledge • Role of artefacts • Interactions (between individuals, among groups, with tools/artefacts) • Perceived barriers/opportunities in DIY • Attitudes towards DIY

These concepts guided and organised initial and subsequent fieldwork as the researcher watched for interactions or events that illuminated these concepts.

7.5 Data analysis strategy: Procedure in Grounded Theory

The first themes and relationships that emerged from initial coding of interviews and documentation collected in the first year and a half of this research yielded the initial grounded concepts of the theoretical framework presented in section 5.3 (p.105). This initial coding, called 'open coding', aims at producing concepts that fit the data: "these concepts and their dimensions are as yet entirely provisional; but thinking about these results in a host of questions and equally provisional answers, which immediately lead to further issues pertaining to conditions, strategies, interactions, and consequences" (Strauss, 1987, p. 28). Therefore it is important that once all the data for all the case studies is collected, these are coded anew. In this research I compared the new themes with the old themes (from open coding) and then reviewed the theoretical framework (verification). This was an iterative process as new data was generated.

The Grounded Theory process is cyclical beginning with an exploration of the phenomenon and then raising 'generative' questions from constant comparison/distinction and triangulation to confirm or disconfirm the patterns, themes, and interrelationships. The

procedure here is 'theoretical integration': which dimensions, distinctions, categories, linkages, etc. are most salient? This begins to yield 'conceptually dense theory'. That is, the creation of 'core categories' to which most other categories and subcategories are related to and which makes it subject to much qualification and modification. It is this which gives it the function of integrating theory rendering it dense and saturated as the relationships are discovered; it leads to theoretical completeness – that is, "accounting for as much **variation** in a pattern of behaviour with as few concepts as possible, thereby maximising parsimony and scope" (p. 35). The iterative process, occurring in parallel with data collection, yielded a synthesis that guided the development of the provisional theoretical framework (section 5.3, p.105), which was then reviewed through the deep analysis of the data and subsequent literature review.

As described above, the assumptions underpinning Grounded Theory stem from SI. It is assumed that reality is constructed and that social processes can be created and changed through interactions. In addition, meaning is created through the use of symbols, people's ability to interpret and position themselves; that is, change, action, and interactions in sociotechnical settings mediates and it mediated by people's reflections on both phenomena and the role of actors (including the self). The focus of Grounded Theory then is the investigation of the context of the setting within which the day-to-day lives of people occur – interactions, behaviours, constructions of reality, and its reconstruction through the researcher's analytical frame. This frame is formed from interests, literature, disciplinary requirements, and the concepts emerging from iterative analysis.

Analysis in Grounded Theory comprises three steps (Patton, 2002): 1) *basic description* resulting from microanalysis (*dimensionalising* and *subdimensionalising*) of the data leads to the generation of initial (and provisional) categories through *open coding* with their properties and dimensions described; 2) *conceptual ordering* is the conceptualisation and classification of events, acts, and outcomes through further open coding (*directed enquiry* and *theoretical sampling*); and 3) theorising by conceiving or intuiting ideas – concepts – and formulating them into a logical, systematic, and explanatory scheme (*integration, saturation,* and *core categories*). The intricacies of this process, in the way I undertook the analysis in this research, are detailed below and are illustrated in Figures 7.6 and 7.7.

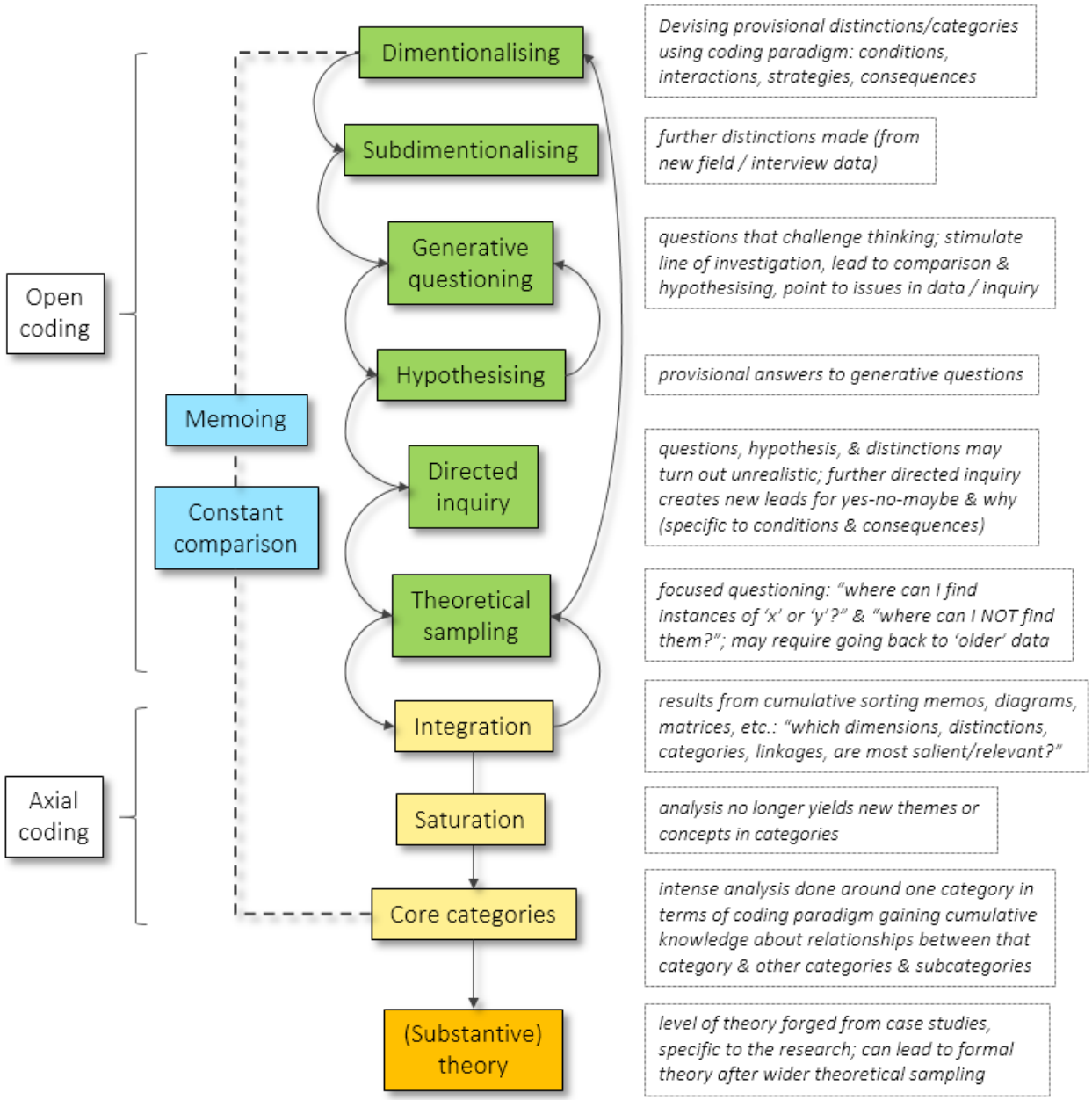


Figure 7.6: Data analysis operations in Grounded Theory. Basic steps and procedures undertaken in this research: development of categories (themes/concepts) systematically interrelated through constant comparison to form core categories. Through integration, core categories render dense and saturated relationships that account for as much variation in with as few concepts as possible; through theoretical saturation these lead to development of substantive theory specific to this research. Based on Strauss (1987).

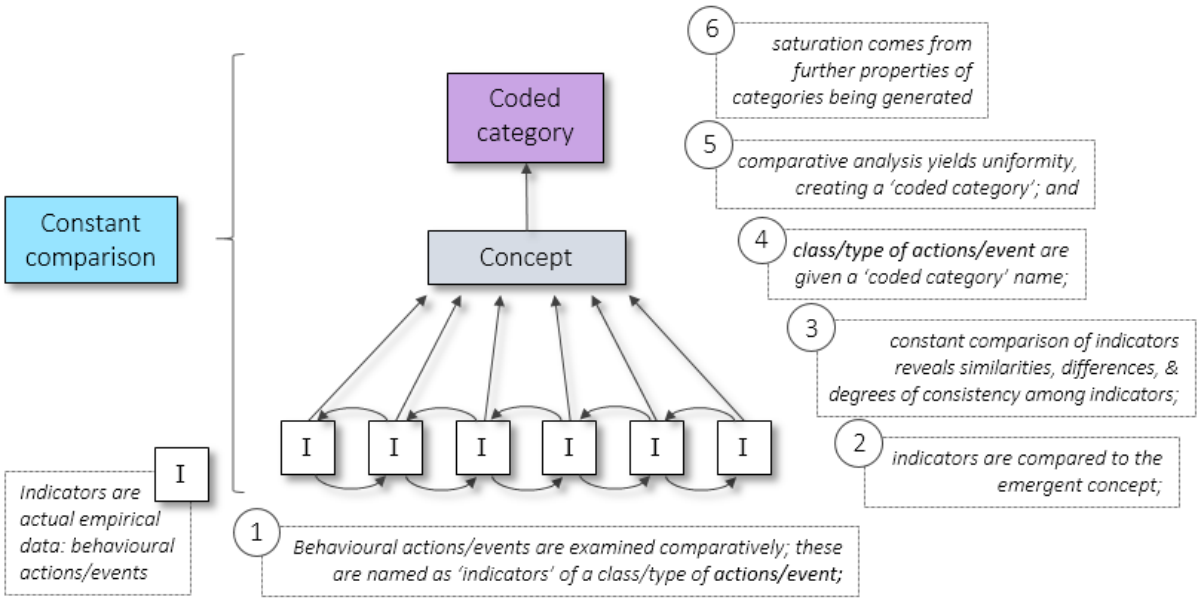


Figure 7.7. The process of constant comparison in data analysis using Grounded Theory. A conceptual code is generated when indicators are compared to the emergent concept; comparison from additional indicators sharpens the code to best fit the data (account for variability) until saturation for that coded category is reached. The latter is the targeted procedure of Axial coding in Figure 7.6. Based on Strauss (1987).

Constant comparative process and memoing. Data collection and analysis are linked through a process of constant comparison; data segments are compared with each other (e.g. between interviews within a case study), with the literature, and with (existing and emerging) theoretical frames. In the early stages it gives shape to the research focus and questions. Further iterations focus and direct the data collection to confirm or disprove provisional concepts and emerging explanations. The comparison between data, literature, and theory[20] is what guides and forges Grounded Theory; comparison intends to clarify differences and patterns that generate explanatory concepts and propositions. It is these movements (tensions, salient points, patterns, gaps, etc.) that are memoed. However, in this research, the strongest use of memos was during the later stages of coding.

Open coding, dimensionalising and subdimensionalising. This involved recording insights drawn from data collected (from observations, interviews, literature, etc.). In the early stages of the research these provided foundational themes and subthemes to organise the data; as more data was gathered and more literature was reviewed, these themes became

[20] This refers to what Strauss (1987) refers to as *theoretical sensitivity* or and awareness of other applications of existing theory or theoretical lenses.

conceptualised (dimensionalised) and nuanced (subdimensionalising). In the process of open coding analytical concepts are drawn from empirical data (conceptualised as *indicators* of actions or events relevant the understanding of DIY enquiry) by constantly comparing indicators to other indicators (Figure 7.7).

Generative questioning and hypothesising. Drawn from personal insights, experience, and literature review, and emergent guiding concepts (Table 7.9), generative questions help to organise the data for analysis and stimulate further directed enquiry. That is, it keeps the researcher generating questions of the data: first, to keep the researcher on track and focused: "what is this a case of?" and "what category does this incident/action indicate?" forcing the researcher to generate codes and relate those to other codes; and second, to 'open up' the data by asking "what is actually happening in the data?", "what is being done here?", "what if this or that changed?", "and with what consequence?" Answers to these are provisional and help to dimensionalise the data, create further coding categories, and confirm, alter, or disprove them. In later stages generative questioning guided further exploration of the relationship between salient core concepts. A sample of the generative questions used in this research are listed in Table 7.10.

Directed enquiry and theoretical sampling. This involves constant questioning of the data and then comparing indicators with other indicators that illustrate the same concept (Figure 7.7). Constant questioning of the data enabled me to seek specific examples or instances of progressively more nuanced aspects of DIY enquiry. This theoretical sampling was an iterative process of deduction (from insights), induction ('testing' provisional answers), and verification (through triangulation with data, literature, and theoretical frameworks).

Axial coding, integration, saturation, and core categories. Axial coding involves intense analysis around one category at a time in terms of the **coding paradigm** (conditions, interactions, strategies, and consequences). This saturates the category but also reveals the relationship between this and other categories. Iterative data analysis saturates and 'prunes' concepts in the categories. As this conceptualisation becomes denser, the linkages between categories and subcategories become more salient, thus revealing core categories (to which many other categories are related and which give the core category explanatory power). The categories that emerge, along with their relationships, are the foundations for developing theory.

Table 7.10: Generative questions for data analysis: sources and types of questions for DIY enquiry

Source	Question theme and sample questions
Coding paradigm	• Grounded Theory: What is going on here? Why is this being done? What if this or that changed? What category does this incident belong to? What is the dimension of this category and how does it vary? What does this action/event illustrate? What are the properties of this concept? What is this a case of? What do I know about this (that allows me to code for it)? What do I not know about? • Socratic questioning of generative questions: Why am I saying this? What do we already know about this? What is the assumption in that? Why choose this code / concept over another? How would this be refuted? What is another way of seeing this? What are the implications of this?
Personal insights / experience	• Barriers and opportunities: What hinders / facilitates engagement in DIY? What are examples of initial steps in entering DIY? What is it like – what types of responses are/aren't people manifesting upon first engaging in it? • Facilitating engagement: What is the role of the facilitator in engaging others in DIY? How are people responding to the facilitator(s)/the facilitation? What is and isn't happening in this setting? • Community development: How do people define community? How do people self-identify - developers, academics, professional scientists, activists, interested, etc.?
Literature	• Engagement: How are people engaged? Are they learning, teaching, using, developing, observing? How do people relate to others and artefacts? What mediates those relations? What is the variety of the people involved? • Role of technologies: What is the range/variety of DIY tools? What the DIY tool development process present/not present? Who, how, when, why? • Production of knowledge: How is 'science' conceptualised? What is the ideology underpinning their response? How is DIY conceptualised? What is the range/variety of this DIY ideology? What do people ask about/question? What do they say they would they like to know/explore/investigate? How do they frame/ask questions? How do they engage in enquiry?
Theoretical lenses / frame-works	• What societal factors are influencing engagement in DIY? How are they manifested/conceptualised? • What is important/meaningful to people? Why? What mediates creation of meaning • What kind of knowledge is this? Is it tacit, explicit, technical, scientific, local? • How are people interacting? Is something being shared (or not)? How do people interact in a workshop environment?

Substantive theory. It is this explanatory power – the theoretical *completeness* which accounts for "as much variation in a pattern of behaviour with as few concepts as possible" (Strauss, 1987, p.35) – that forges theory. In this research the level of theory forged from case studies,

was specific (substantive) only to this research topic, context and settings investigated. To forge formal theory, wider theoretical sampling in a wide range of areas (multiple fields) and from multiple sources of evidence must be carried out. I outline some of these opportunities for further research in the concluding chapter.

7.5.1 Using Atlas TI software for data analysis

ATLAS.ti is a qualitative computer software package used to manage and analyse the textual data. In this research the software was used for:

- Managing all textual data in this research;
- coding textual sources of evidence and create quotations;
- creating coding categories to help with theoretical sampling;
- producing network views of categories and subthemes to aid integration and saturation of theory; and
- using query tool, co-occurrence explorer, and code manager to aid in the analysis of code groundedness and density (see Appendix A.4).

Although the software includes a memos function, these were done separately using a word-editing programme. ATLAS.ti was particularly useful if creating the integration diagrams (see Appendix A.5 for an example), which provided a visual and dynamic format to organise codes for building and checking relationships between codes, theoretical sampling, and then identifying core categories.

7.6 Research quality

Mårtensson et al. (2016), proposed a model to describe what constitutes research and research practice in a multidisciplinary context: credible, contributory, communicable, and conforming (Figure 7.8). Their definitions and assessment in this research are presented in Table 7.11.

Figure 7.8: Assessment of research quality. Based on Mårtensson et al. (2016)

Table 7.11: Research quality criteria as applied to this research. Based on Mårtensson et al. (2016)

Research quality criteria			This research...
Credible	Rigorous	*Internal validity* - research design is in direct relation to research questions	Links research questions with methodological case study design as shown in Figure 7.5
		Reliable and *contextual* - Research design chosen is appropriate for questions and context and its procedure is described so others in similar context can use it	Gives extensive detail on 'methodological practice' linked to 'methodological theory' (Chapter 6) stemming from supporting literature and guidance from Patton (2002); rich description of context provided
	Consistent Coherent Transparent	The new knowledge produced is provable; research acknowledges-, is linked to-, and expands existing	Presents sources of evidence; Is linked to-, and expands existing knowledge (Figures 2.1, 3.1, and 4.3);

		knowledge; research is in accordance with the methodology selected & research questions, and describes the process of linking methods, questions, & results	Figure 7.5 links methods and questions; Chapter 14 answers research questions and links back to literature; Case study chapters (8-9, 10-11, & 12-13) follow data collection and analysis procedures in Chapter 7 & describe how they are used
Contributory	Original	*Original idea* - Research questions have not been asked before in current context or are interpreted in novel way *Original procedure* - Methodological procedure is original in relation to research questions *Original result* - New Knowledge is provable in relation to- and adds to existing knowledge	'DIY enquiry' is a new conception defined in the context of the digital age & current trends in society (section 1.2); no previous research on DIY has used the developed methodological design but design is grounded on established methods; contributions to research are listed in Table 15.1
	Generali-sable	New knowledge is practically or theoretically useful in contexts other than the one studied	As outlined in section 7.5, theory produced is specific (substantive) only to this research topic, context & settings investigated. Forging formal theory requires wider theoretical sampling in multiple contexts; New knowledge on applying known methods & literature in new ways is generalisable
	Relevant	*Relevant research idea* - Research questions relevant for current 'target group' (beneficiaries) *Applicable result* – Results are beneficial (has positive effect) for the current 'target group' *Current idea* - Research questions in accordance with current context	Those who may benefit from the research include academics in social science, technologists, educators, community organisers, participants of this research; compilation of literature reviewed of relevance to participants; research & method linked to addressing problems with current social trends
Communicable	Consumable	The research is structured & follows research methodology; its language is understandable and readable for those who benefit from the new knowledge	The language employed is for an academic audience and may therefore not be readable to all those who could benefit (this research will need to be adapted to make it accessible)
Conforming	Ethical Sustainable	Research complies with currently applicable ethical standards; Produces practical knowledge useful for sustainable practice or organisational/community change	Ethical considerations are outlined in section 7.8; as above, while this research offers practical and scholarly contributions, these need to be adapted for wider audienceship

7.7 Limitations of the study

7.7.1 Researcher bias

The researcher's background and relationship with the community will limit the type of data collected; the themes and patterns identified are coloured by the researcher's background, experiences and worldview (i.e. historicality).

McCracken warns that "those who work in their own culture do not have critical distance from what they study. They carry with them a large number of assumptions that can create a treacherous sense of familiarity" (1988, p. 22). In this sense, the investigative capacity of the researcher can be limited by their historicality as well as who and what they already know. To avoid this bias, McCracken (1988) proposes 'manufacturing a distance'. That is, disassociating oneself from a familiar setting or culture by immersing into another. Upon returning, the researcher is able to see the peculiarities and the arbitrary character of the world around her. Looking at something once familiar through another perspective from another culture enables the creation of a distance or new perspective. For this research, the researcher entered and exited the case sites and after having interacted in other settings, was able to build distance and a refreshed perspective (e.g. every year at the Public Lab annual community gathering). Hence, while the researcher was familiar with the social behaviours and the settings, the new/changed perspective allowed her to engage with curiosity and be surprised.

7.7.2 Limitations on data collection

In this research it was assumed that the researched individuals, groups, and organisations were effectually engaged in DIY enquiry through their activities. It was also assumed that the participants were dynamic in their engagement and their learning. It was additionally assumed that if during an interview or group discussion, a concept, person, group/organisation, or phenomenon was recurrently mentioned then they are relevant should therefore be included in the study. However, not all sources of evidence came from 'snow ball' effect (i.e. referred to cumulatively by others). In my wanderings, especially in the place-based case, I came across other sources of evidence and gained insight from local residents and passer-bys.

I also became aware of the concepts that were introduced to participants e.g. DIY or 'citizen science' and how they used/interpreted these terms. The sampling strategy and data collection methods of this research were limited by the availability of time and resources. In addition, not everyone identified as a community member or stakeholder would have wanted or would have been able to participate. Not being familiar with the setting meant not all situations of interest were observed. I am also aware that the events chosen for data collection imitated who was there and the circumstances under which they participated.

Being an active member of a community of practice provided me with a deeper understanding and interpretive capacity; I was able to take for granted my own 'Western' worldview but I also projected my own cultural bias onto the cases. Carrying out research in another context outside my own culture (without the sense of familiarity) could, in future research, reveal new themes and patterns – what was missed in other cases, and what does not apply under other circumstances. Participant observation as community member also provided an opportunity to recognise the limits of ontologies and epistemologies as an academic by contrasting it with practice as community organiser who reifies lived experience and appreciates non-Science forms of knowledge. As both an academic and community organiser, I reconciled the difference in approaches and 'objectivity' by often discussing and exploring research tensions – with my supervisor, other peers, and participants of the study.

Specific to the playshops, participants to the playshops were self-selecting. That is, no one was actively recruited based on specific criteria; people signed up to the events out of their own interest or were invited to participate by the facilitator at related events, such as science film nights. In addition, because I was interested in studying the experiences of prolonged and sequential engagement in DIY enquiry, only those who had completed at least four playshops were asked for an interview. This means only the views of those who were able or willing to continue their engagement have been recorded, excluding the views of those who did not continue their engagement. However, while the views of those who could not or did not wish to take part in the playshop would have added useful insights into the barriers for engagement in DIY enquiry, indirect views and perspectives on participation and engagement of others were collected from those who were interviewed. Each playshop had 'reflective group discussions' allocated, where participants shared reflections on their experiences. Thus, all playshops had a unique character; no playshop was the same as the last.

7.8 Ethics

Ethics in qualitative research guides decision-making in research - from problem formulation to data gathering and analysis to presentation of results. It dictates the humane considerations for participants and the representation of the results. Although the purpose of research is to contribute to knowledge, improve practice, benefit participants, etc. there is a limit to how much is uncovered. Ethics is also about selecting what stories not to uncover. The integrity of this research was based on the honesty and openness with which the researcher shared results from this research with corresponding participants to ensure that they were not being misrepresented. In addition, all field notes, recordings, and transcripts are not being made publicly available. Sharing results with participants served several purposes: validation by community/participants; avoid extractive research; giving back to the community/participants in a way that is productive or constructive for their own practices while preserving an accurate representation of the phenomena under study.

This research fulfils departmental practices on accepted ethical standards for 'informed consent', 'benefit not harm', and 'confidentiality' but without the physical forms. All participants were informed about this research; those who were interviewed acknowledged their participation in the interview at the beginning of the recording, those who participated in group discussions participated under the condition that the results would be fed back to the community. The identity of all participants is protected in this thesis and the identity of those who were interviewed is kept confidential to others in this study. Participants were given information about the research (including purpose, duration, researcher affiliation, type of participation, confidentiality[21] safeguards, potential harms and benefits, and possibility to withdraw) so that potential participants could give free and informed consent prior to taking part in the research. To be inclusive and realistic, I sampled as widely as was possible, to give representation to the different voices of participants in the research setting.

The summary of the methodological practice is summarised in Table 7.12.

[21] Confidentiality involves both protecting the identity of participants and refusing to reveal sensitive information gathered during the research process that could harm the individuals involved.

Table 7.12: Overview of methodological practice

Methodology stage	Approach / stance
Fieldwork strategy & data collection	Multi-method approach — researcher as participant, researcher as facilitator, researcher as observer; instruments: semi-structured interviews, participant observation, document analysis, field notes, and workshops
Data analysis strategy	Qualitative analysis using Grounded Theory
Data analysis procedures	Coding of interviews, field notes, secondary data (official documentation, blog post, 'research notes', mailing-list discussions, and reports) using ATLAS TI software; triangulation and focus group for validity

We now move onto the case studies, starting with Community of DIY practice background (Chapter 8) and case analysis (Chapter 9). Chapter 9 presents the Grounded Theory for this case study explaining how culture and practice are embedded within interactions, framings, and factors that enable and promote it. Culture and practice represent the actions, roles, and members of the community as well as the tools and infrastructure, narratives and meanings, productions of knowledge, and know-how/ skills. The Grounded Theory also portrays the relationship between culture/practice and values held by the community.

8. A community of DIY practice: Case study background

The Public Laboratory community is a case demonstrating the processes, interactions, and framings of science and technology in an actual community of practice engaged in activities of socio-technical DIY. The case reveals initial insights into the salient themes of DIY enquiry such as the way expectations and meanings of practice shape its potential and how DIY and professional practices are juxtaposed. It represents how individuals interact in a grassroots community using and developing DIY tools as well as how techniques of DIY enquiry are represented as both an end (personal pursuit) and as a means (collective/organised action) to address issues of social and environmental concern. This chapter presents the background information for this case study including community organisation, setting, practices, infrastructure and tools, and events analysed in this research. It also presents the case study contribution to research, design frame, and list of sources of evidence.

8.1 Beginnings

Public Lab, as it is known by its community members, is a grassroots organisation originally spurred by the British Petroleum (BP) oil spill in 2010. Local residents, members of community groups, students, and people whose livelihood depended on the area surrounding the Gulf Coast of Louisiana, gathered to address the media blackout and lack of information about the extent of the damage. Led by community organisers, they explored and further developed tools and methods to collect and disseminate data about the state of the oil spill and its longer term impacts. One of these tools, DIY aerial mapping (Figure 8.1), was supported by a Kickstarter campaign, which not only helped to raise awareness about the environmental disaster but also the grassroots approach and technique to address the lack of publicly available data. Through this initiative they collected over 100,000 aerial images of the coastline. The images were 'stitched' together to create large high-resolution maps (Figure 8.2) that "provided an independent source for monitoring the effects of the spill" (Boaden, 2015).

Figure 8.1: Fishermen and community organisers working together to map the wetlands skirting the coast of Louisiana: a kite with a camera attached to its line is tethered up to reach a height of between 300 and 600 meters. [Source: Public Laboratory].

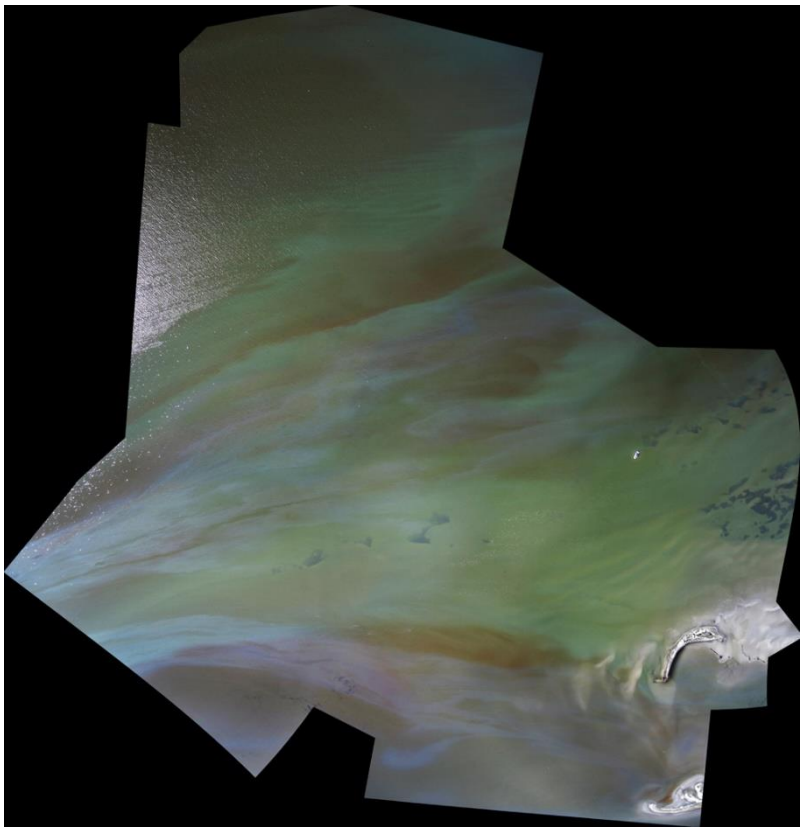


Figure 8.2: Aerial photographs comprising a map of the BP oil spill in 2010. [Source: Public Lab].

In their own definition, Public Lab is "a community which develops and applies open-source tools to environmental exploration and investigation. By democratising inexpensive and accessible 'Do-It-Yourself' techniques, Public Laboratory creates a collaborative network of practitioners who actively re-imagine the human relationship with the environment" (https://publiclab.org/about). It was "founded by a group of activists, educators, technologists, and community organizers interested in new ways to promote action, intervention, and awareness through a participatory research model" (http://grassrootsmapping.org/). Since 2010 the group has continued defining and refining this vision as their ideas, ideals, and techniques has spread to over 15 countries (www.publiclab.org).

8.2 The community and approach

The group identifies itself as an open source community and it is supported by a non-profit organisation that provides the administrative, physical, and digital infrastructure for their work (more on this below). Part of their approach is based on Fortun and Fortun's (2005) concept of 'civic science': doing a kind of science that questions the state of things, rather than a science that simply serving the state. The group actively frames itself as an alternative to the "typical approach" to public participation is science:

> So in our model we encourage people to work along the entire research continuum- so from asking questions, identifying what the problem or issue in your community- your neighbourhood might be to looking at the landscape of tools that might be available to do monitoring and if they aren't available then *make* them – so building the hardware tools, creating the software analysis platforms, going out and doing the data collection, processing, interpreting, analysing data and then working towards drawing conclusions that will help lead towards actionable goals [11:14].

Since its formation in 2010 the group's exploratory and collaborative spirit continues throughout the years focusing on active partnerships collaborating around pressing issues such as particulate monitoring, oil spill and wetland conservation mapping, and coal pile measuring. As they state in their 2015 annual report, to continue supporting community groups, the organisation has taken huge strides towards maturing as an organisation

> welcoming a new focus around data advocacy into Public Lab. The launch of this program area has proved important in providing critical support for groups who are advocating for positive change in their communities by supporting people as they ask

> questions, interpret and decipher the information available, gather new data, and present it in ways that will be impactful. From a refugee camp in Lebanon using data to advocate for green space to aerial images supporting litigation around a polluting coal terminal in Louisiana, it has been impressive to see the range of ways that community science has brought people together to be actively engaged in sculpting the future of places they care about (Public Laboratory, 2015).

The group, in particular the founders, staff and active community organisers, have also published several journal articles documenting and grounding their work (e.g. Breen et al., 2015; Dosemagen et al., 2011; Wylie et al., 2014). There are currently over 6,000 people interacting in the online platform (publiclab.org) and through local communities, most of which are based in the United States. Their challenges and aspirations include the continued recruitment and retention of community organisers as well as the "putting substantial time into ensuring publiclab.org is easy to use and a great resource for community science and open hardware practitioners" (Public Laboratory, 2015). The level and from of engagement from these members varies greatly and includes contributing to various degrees of programming in many of the online platforms (described below), developing and delivering engagement activities, trying out tools and sharing their experiences through 'research notes' online, commenting on 'research notes', attending events, lobbying, and acting as a 'Public Lab community organiser'. I explain the latter next.

8.2.1 Public Lab organisers

Public Lab organisers are community members "who are leaders in the Public Lab community, and have an interest in the way our community collaborates and grows. As of 2015 there were 67 organisers from 11 countries. Typically but not exclusively, these are people who are both key organisers in their local communities as well as key contributors to the broader Public Lab community" (www.publiclab.org). The role as 'organisers' includes hosting events, moderating online discussions, sharing their skills and knowledge with others, and "help shepherd the Public Lab community in other ways" (ibid). Organisers use various channels of communication including weekly online calls and mailing lists through which they share their work, pose questions, seek help or collaborations. Organisers contribute to the discussion about Public Lab practice (e.g. value statements and mission) which shapes the community's identity but they are also instrumental in connecting Public Lab to other groups, organisations, and contexts. The main 'requirements' to become an organiser are: demonstrated contributions to the community online or offline, "embrace Public Lab's work and exploration, and […] contribute to the activity and diversity of the organizer's group"

(ibid). Organisers also have a dedicate 'space' to discuss and exchange face to face at the annual Public Lab gatherings (detailed below). The interviewees for this case study are all organisers contributing to this community of practice.

8.3 Public Lab community infrastructure, tools, and techniques

The efforts in the Gulf Coast began with two techniques, namely aerial mapping and spectrometry. The former was brought in by a volunteer as a skill, the latter was conceived during the initiative:

> one of the team members helping out on the front line [explains:] "We started with balloon and kite mapping, but... other things came up," [...] "People would come across residues on the beach or dead fish or animals… and they wanted to definitely say that this is crude oil and link it to this spill. So we literally started googling, 'How do you identify oil?'" (Boaden, 2015, p. 1)

The efforts during the oil spill also led to the creation of the Grassroots Mapping project, now a community of mappers around the world. The mapping technique involves using low-cost meteorological balloons and large 6 and 9 ft. kites to collect aerial imagery. It follows various steps. First, a site is selected by either local 'community mappers' themselves or by external visitors interested in certain aspects of a site (e.g. pollution from a refinery or experienced mappers visit and pass on their skills to local farmers, environmental groups, etc.). A kite or a balloon tethered to a kite line is launched to a height between 100 and 300 meters with an ordinary camera secured to a rig attached to the line; the camera, set to continuous mode, has its shoot button held down by a rubber band. The mappers walk/canoe/cycle around the area they wish to map, retrieve the camera to select the imagery, and upload it to the free, online open-source software, 'MapKnitter' (www.mapknitter.org) to 'stitch' a map together from images selected. The map can then be published online in the public domain or privately and securely. Maps and mapping efforts/techniques are shared online and quarterly in print through their publication 'Community science forum: Public Lab Journal of Environmental Research' (previously known as the 'Grassroots Mapping Forum').

There are 27 tools at different levels of development (sample shown in Figure 8.3). Created by Public Lab contributors, they range from established prototype hardware such as 'near infrared camera conversions' (DIY NIR) for plant health monitoring and the recently developed 'Riffle', an open source data-logger to which monitoring sensors can be connected (to measure temperature, conductivity, turbidity, etc.), to newer software such as 'WebJack', which creates a bidirectional data link between the Arduino Uno board and a mobile device via headphone jack.

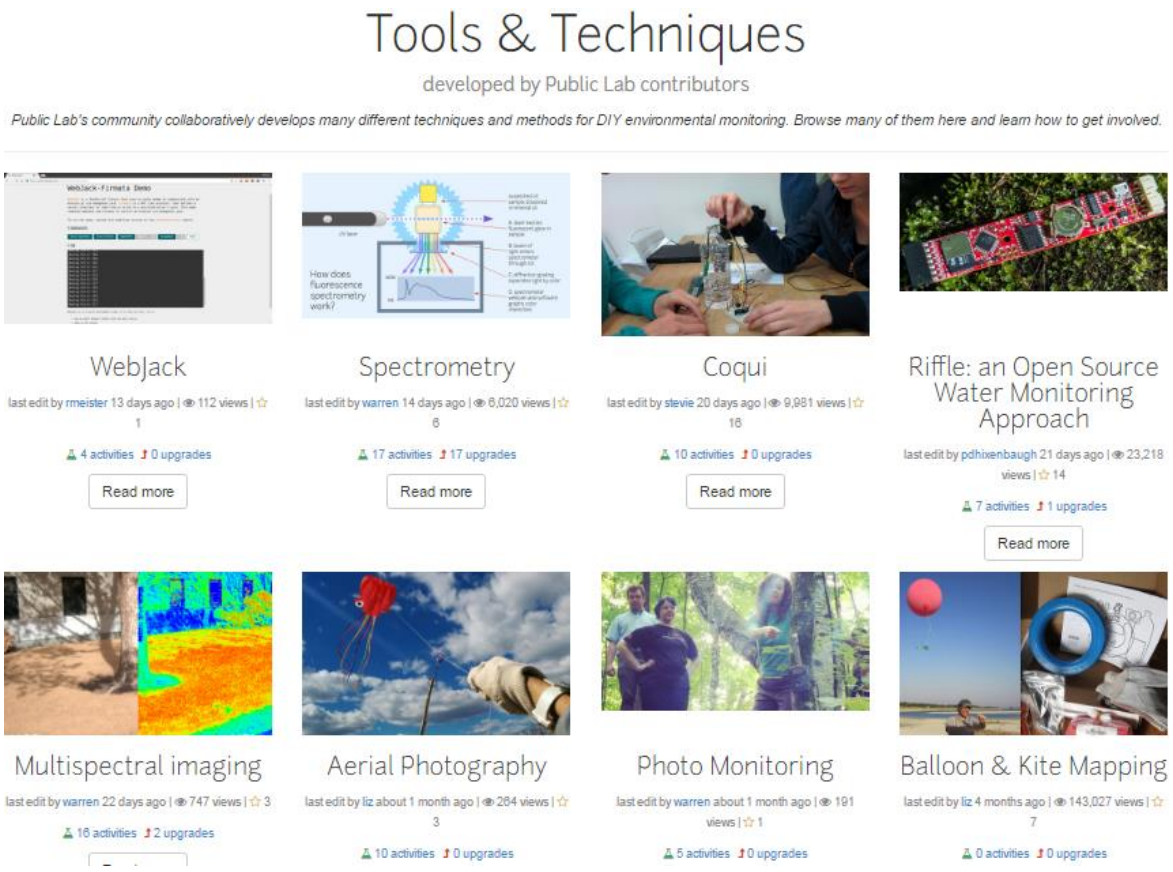


Figure 8.3: Public Lab tools at https://publiclab.org/tools.

Public Lab's online interactions occur through publiclab.org, a wiki-style web platform to which contributors add 'research notes'. These online contributions include advances in or presentation of new tool developments, findings from experiments, tutorials, community event descriptions, descriptions of sites where members are working, annotated maps, etc. 'Research notes' are mostly community written in English with increasing translations and contributions in Portuguese and Spanish. The platform also connects to web-tools for data

processing: aerial imagery (www.mapknitter.org), NIR imagery (www.infragram.org), and spectrometry (www.spectralworkbench.org).

Discussion about concepts, methods, tools, and upcoming events also take place through several of their outreach channels. For example, mailing lists. As of 2015 there were >4,000 people signed up to the googlegroup in which there are 33 mailing lists with topic-based mailing lists and place-based mailing lists (Figure 8.4).

Another outreach and dissemination channel is the monthly Public Lab 'Open Hour' video conferencing. Open hour has between 5 to 20 guests live on a call (depending on the topic) with dozens more people listening live and contributing comments/questions via the live chat.

Offline activities include face-to-face gatherings for tool and concept development such as their 'Barnraising' events (detailed below). There are also contributions of articles (e.g. on lessons learnt and success stories), techniques (e.g. how to determine waste piles from aerials and ground), or other data to their quarterly journal mentioned above.

The most recent development in their infrastructure comes from the pressure of making meaningful and useful sense of "the sheer number of posts on publiclab.org by contributors from all over the world about 1) how to build tools better, and 2) how to use them for making environmental observations". It is described as "breathtaking, and at times, boggling". They identify the problems that "as Public Lab has grown, so much content has been generated that it has become unnecessarily difficult to know what the "latest and greatest" version is, what the next development challenges are, or simply where newcomers should begin" (www.publiclab.org). To this end the community has been writing new features on the platform to organise these research notes into activity type, status of its documentation, and how many people have replicated it. Other features track upgrades and questions "to make it easier to get involved" (ibid). These changes in practice and identity have stemmed from "long and hard conversations" [2:34] which make part of this case study. Much of Public Lab's work revolves around the tools which support its monitoring/investigative efforts on- and offline but it is the 'open source and accessibility' ethos (Figure 8.5) and community culture of collaboration that plays a bigger role; Public Lab directly aims at addressing the issue of barriers to public participation in decisions about their environment and problem-solving.

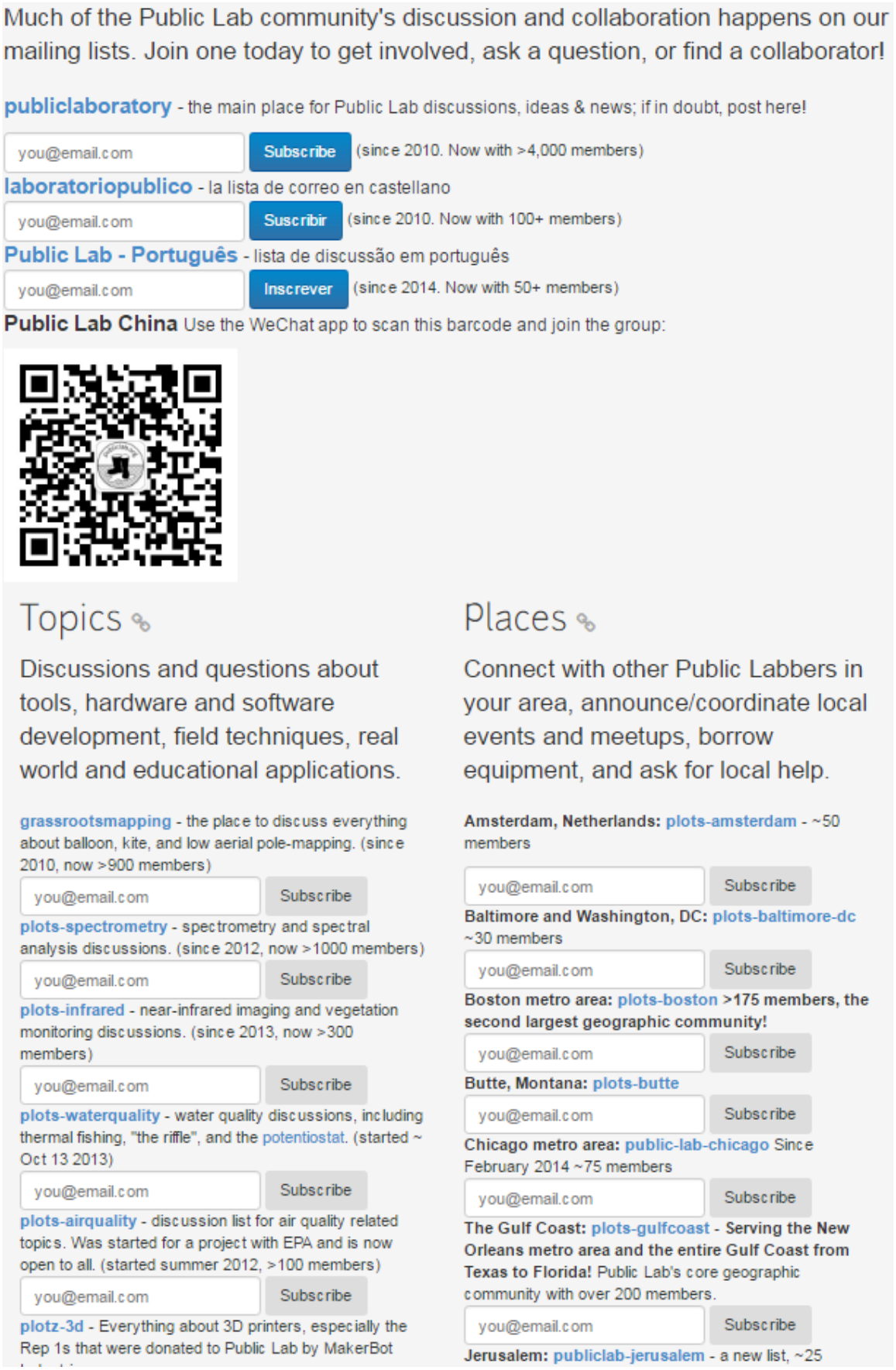


Figure 8.4: Public Lab mailing lists at https://publiclab.org/lists.

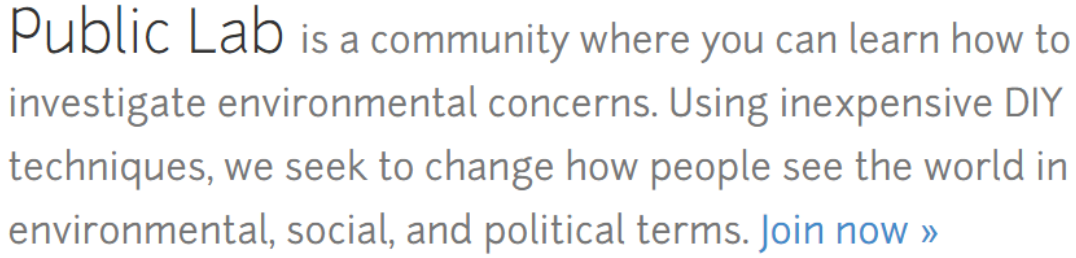


Figure 8.5: Public Lab ethos as introduction on their website (https://publiclab.org).

8.4 The Public Lab Barnraising

The Public Lab Barnraising gatherings are "the closest thing we have to a Public Lab conference but with an emphasis on 'doing stuff together'". The aim is to open up a dedicated space to exchange ideas and technical knowledge, build networks and collaborative ties, engage in hands-on problem-solving and rapid prototyping of software and hardware, sketch out new projects, discuss experiences, tactics, and stories face-to-face. People join in from different regions in the U.S. and internationally. The main characteristic of the event is its 'unconference' style in which the structure and schedule of the event is determined by the participants at the beginning of the event – based on their interests and needs and so that activities can be targeted to specific issues. There are 'Regional Barnraising' events around the U.S., which are focused on a particular community and/or theme, and there is a larger annual event organised at the birthplace of the group, in Cocodrie, Louisiana. As a community organiser, I have attended four of these annual gatherings.

The annual Barnraising also includes an 'Organisers' summit' pre-meeting – a space dedicated to Public Lab community organisers to hone in on Public Lab community-related issues such as revising value statements and the state of the community (e.g. stats on growth and depth of engagement), identifying specific skill needs and opportunities for sharing, and developing an 'organiser's handbook'.

In the next chapter I present the analysis from interviews of Public Lab organisers at Barnraising events, field notes, and articles from this community of practice as they interact with each other, their tools and techniques in different contexts and in doing so, they (re)define what the community stands for.

8.5 Methodological strategy: A community of DIY practice

Contribution to research: Through this case study I further developed themes in the upper left and right quadrants of the theoretical model – 'symptoms of the state' and 'status of science' in Figure 5.1 (p.107). This research highlights the tensions between citizen-led enquiry as a form of scientific research and the practices in professional/institutional science in terms of expectations and meanings that shape both. Observations from this case study also added to the bottom left and right quadrants of the theoretical framework in Figure 5.1: 'cognitive/technical mastery' and '(self-)trust'. The research highlights the tensions in the way DIY is conceptualised as a practice in the spectrum between DIY as a means to achieve something or as an end in itself. Insights from this case study in relation of the theoretical framework in Figure 5.1 are discussed in the book chapter "Getting out of their way: Do-It-Yourselfers, sensing, and self-reliance" (Regalado, 2016). Insights from practices of the community are also described in the journal article "Promoting playfulness in publicly initiated scientific research: for and beyond times of crisis" (Regalado, 2015).

Selection rationale: This case study was selected because it provided an understanding of processes and interactions in an actual community of practice engaged in activities of socio-technical DIY. It represents how individuals interact in a grassroots community using and developing DIY tools as well as techniques of DIY enquiry as both an end (personal pursuit) and as a means (collective/organised action) to address issues of social and environmental concern.

Design frame: This case study is local as I have gained personal knowledge and operate within its community. It is a key case because it exemplifies a community of practice in socio-technical DIY, providing a unique perspective into the practices of DIY supported by a community with interactions, framings, meanings, and tools. The purpose is instrumental in that it contributes insights at the organisational and community of practice levels that complement the perspectives of the other cases (at the personal/group and real-world context community levels) in the understanding of the broader picture of DIY enquiry. It is an exploratory case as it helped to guide research through the identification of themes and categories of DIY enquiry in a community of practice context: e.g. conceptualisation of science practices (relation between 'canonical' and grassroots science) and conceptualisations

of DIY practices (DIY as a means or as an end). The case also provided ways to further, through *generative questioning* (see section 7.5, p.162), an understanding of the relationships between these concepts and practice. Its purpose is also exploratory in that it provided an opportunity to iteratively explore, first-hand and over time, the various processes of knowledge production and the role of technologies in a community of practice. All empirical data from this case was used in the theory-building approach of Grounded Theory. The case is part of multiple parallel case studies with elements of research interest nested across cases. The design frame is illustrated in Figure 8.5.

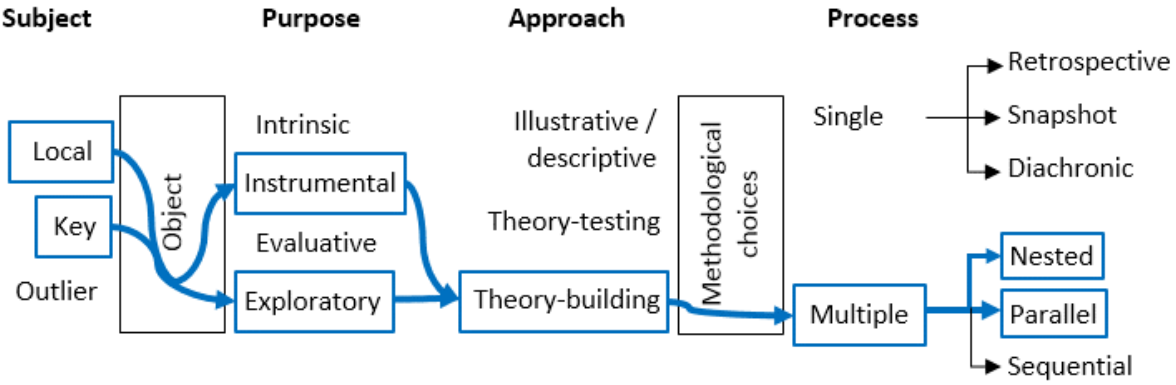


Figure 8.6: Research design for community of DIY practice case study.

Sources of evidence: Long-term direct immersion in this case study enabled me to collect many sources of evidence to analyse and triangulate findings. These are listed in Table 8.1.

Table 8.1: Sources of evidence for community of DIY practice case study

Data type	Description	Year
Documents / Reports	• Public Lab overview: outlining mission, vision, approach, philosophy • Co-authored article "DIY Science: An empowering practice" • Compendium of value statements from the Public Lab community • Public Lab Annual report 2013 • Online discussion on 'Public Lab Cartography Collective' – challenges to engaging in & 'sticking' with full cycle of community mapping process • News articles reporting on the application of Public Lab DIY prototypes to environmental problem-solving • Public Lab Annual report 2014 • Grassroots mapping forum – quarterly journal by Public Lab community	2011 2013 2014 2011-16

Data type	Description	Year
Blog posts	• Blog post on my first experience at grassroots mapping with Public Lab founders • Blog post - reflections on grassroots, civic science, and DIY mapping as a new activity for me • Reflections on my experiences trying out & 'becoming' a kite-mapper • Description & reflections on doing kite mapping workshops at the Mildmay community centre and through Citizens without Borders	2012 2013 2013
Audio recordings / interviews	• 2 group discussions on Near Infrared prototype state and development – technical and software challenges, environmental applications; DIY in real-world applications • 1 in-depth interview with Public Lab community member on their project, challenges, grassroots science, tools use in social context • [3 interviews & 2 group discussions lost due to software issues] • Conversation with Public Lab founder on history of development of DIY spectrometry prototypes • 3 group discussion on: sharing information (issues, tools, methods, etc.), openness, accessibility, community engagement; doing grassroots research & research communication; issues of participation– at annual event Barnraising 2014 • 6 in-depth interviews with Public Lab community members (*interview guide based on theoretical concepts and framework*) • Validation workshop focus group deliberations • Conversation with Public Lab staff re:research findings – triangulation	2013 2014 2015 2016
Video interviews	• 4 in-depth video interviews with members of the Public Lab community about Public Lab - what it is, what does, how it does what it does at annual event Barnraising 2013 • 4 video interviews with members of the public about their participation in full-day DIY aerial mapping workshop imparted by Public Lab staff • Video and photographs of DIY aerial mapping workshop: kite-making, kite-mapping (hardware), map-making (software) • 4 video interviews with members of the public about their participation in DIY spectrometry workshops imparted by Public Lab staff • Video and photographs of DIY spectrometry workshops: spectrometer-making (hardware), spectral analysis (software)	2012 2013

Data type	Description	Year
Survey	• Short online survey with Public Lab kite-mapping & spectrometry work-shop participants on reasons for engagement & workshop expectations	2013
Photos / video	• Video and photographs of workshop at Citizen Science Summit on building a Public Lab prototype: DIY thermal flashlight • Conversation on DIY tools; demo of tool for DIY kites for kite-mapping • 4 group discussion on; Civic Science and (difference with) Citizen Science; on participation, what is science, how action is taken; organisation's statement, what organisation does, nature/role of tools, practices, processes; and sharing and dissemination, 'open' – at annual event Barnraising 2013 • Video of Public Lab Barnraising activities incl. testing DIY spectrometer for flare spectrometry (pollution from smoke stacks)	2012 2013
Field notes	• Observation notes and reflections on Barnraising events 2012-2015	2012-15

With this background on the study of a community of DIY practice, we move to the case study analysis, which offers a Grounded Theory explaining the phenomena in this community.

9. A community of DIY practice: Case analysis

9.1 Comparative process and research dimensions

I will begin the analysis by presenting the guiding concepts developed and used in the study of individual and community engagement in DIY. Initial questions about community engagement in DIY enquiry are also presented followed by an introduction to the theoretical sampling process for this case study.

9.1.1 Initial guiding concepts and preliminary conceptual model

I began immersing into the world of DIY in 2012 through hands-on experimentation with DIY electronics (Figure 9.1) and by conversing with self-identified 'makers' and 'technologists'. I became aware of the powerful effect of 'hands-on engagement' but also wondered about the 'identities' of DIY culture. The next chapter delves into hands-on engagement. Through my engagement with Public Lab from late 2012 I became specifically interested in the functions and relationships that I observed within its community. Through group discussions, literature review (academic and popular), and one-on-ones with community members and academics, I explored a series of questions and qualms about the DIY culture/movement in general and the practice of DIY in communities of practices specifically.

I developed an initial concept map identifying six roles or perspectives on the DIY culture/movement, namely, the 'doers', the 'supporters', the 'hype', the 'sceptics', the 'disbelievers', and those 'who do not know' about the DIY movement. My colleague Christian Nold pointed out a seventh category: the 'in between people'. These are illustrated in full format in Appendix B.2. From further work on the playshops (next chapter) an additional sphere of engagement was added: 'the first-timers' of DIY – those who begin exploring DIY and might or might not continue engaging in it.

The 'doers' who influenced my thinking during the initial stages of this research (Figure 9.2) include members of the London Hackspace, community members involved in noise and pollution monitoring through the social enterprise Mapping for Change, members of the

ExCiteS team co-developing a mapping app in Africa, and the Public Lab community (or PLOTS – its original acronym) who, at the time, were refining DIY aerial mapping and spectrometry techniques. From learning about their work, several additional guiding concepts emerged: their *actions* such as *monitoring*, *sensing*, and *advocacy*; *strategizing* and planning for data gathering, and *DIY tool*-making and deployment. Actions such as presentation of results, seeking *credibility* and *impact*, and *working together* to gain and provide *support* also began to shed light on the processes that shape a community of DIY practice. 'Communities of practice' are defined as groups of people who share a concern or a passion for something that they do and learn how to do it better as they interact regularly (Wegner et al., 2002).

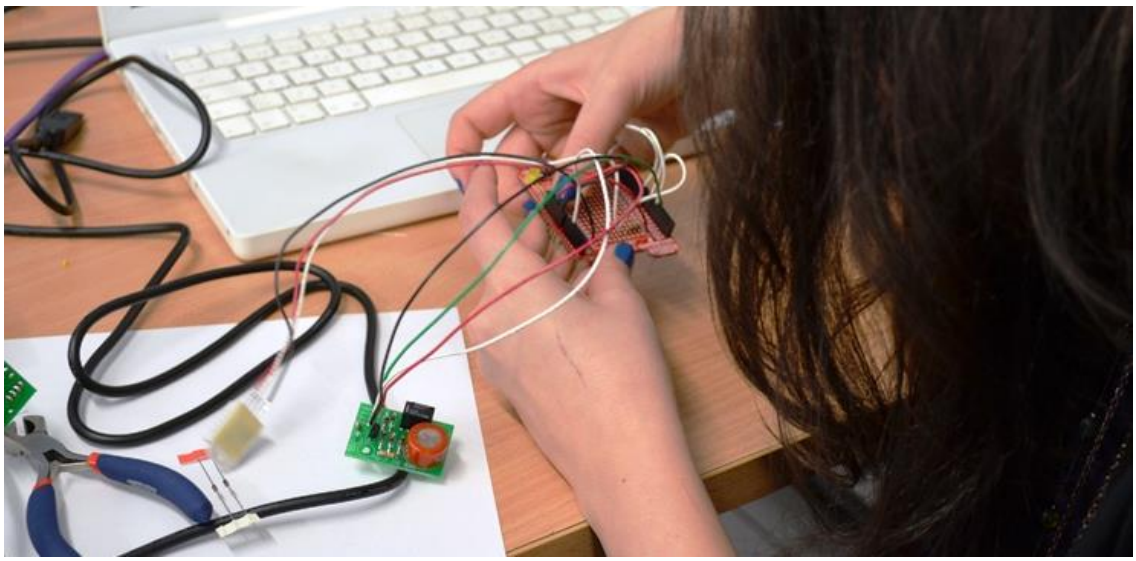


Figure 9.1: Making an 'air quality egg'; workshop March 2012 in London [Credit: Cindy Regalado].

These insights provided the foundations for initial propositions (hypotheses) on the processes that shape Public Lab as a community of DIY practice. First, I proposed that there are internal and external roles. Internal roles involve first-timers and doers; doers mentor first-timers, who might then become doers engaged in tool-making, monitoring, and/or advocacy. External roles include supporters, the 'hype', the sceptics, and the disbelievers whose perspectives influence and shape the community e.g. improving community data-collection methods in response to scepticism about rigour.

Second, there are internal and outward interactions. Within the community interactions occur online (through platforms and mailing lists) and offline (events/gatherings). These interactions provide the rhetoric and identity as well as the ethos that guides the community's actions and tool use and development. Outward interactions are about promoting the

community's work and technologies to reach new community organisers and cultivate new partnerships (e.g. potential funders, supporters that provide resources and credibility).

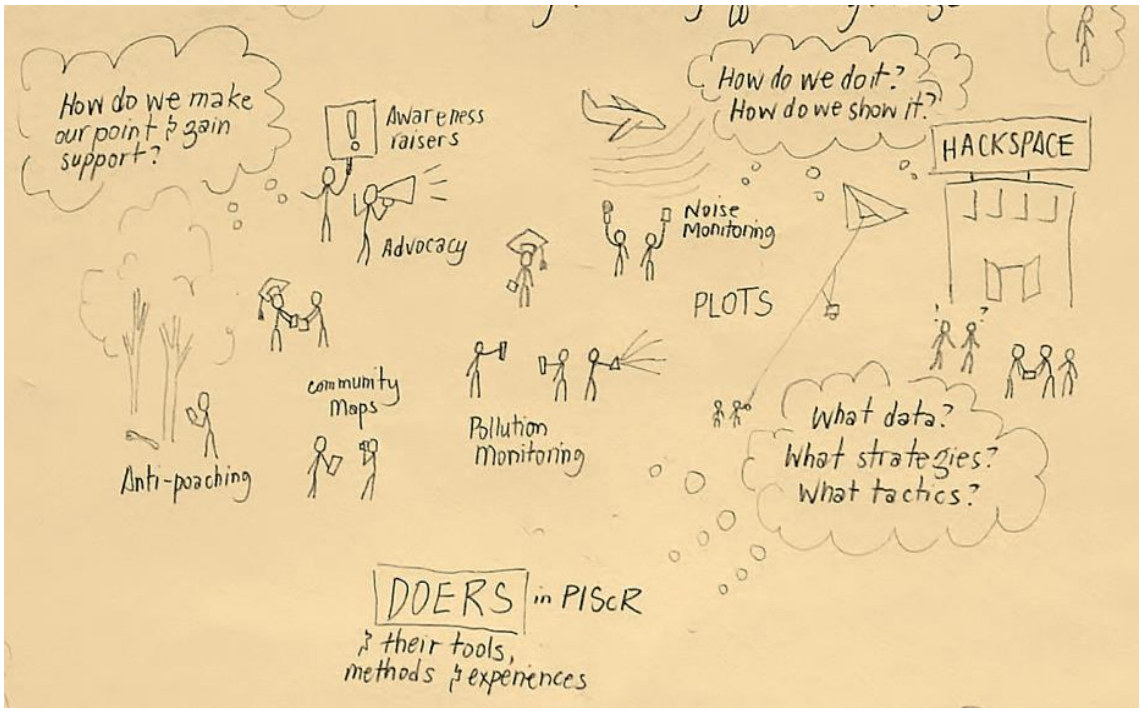


Figure 9.2: Initial guiding concepts; aspects of the DIY moment: *the doers*, their actions, and concerns. Original sketch by Cindy Regalado, February 2013.

Third, there are physical tools such as DIY aerial-mapping kits and online software such as MapKnitter.org; the community strives for these to be open source and this shapes their design, relationship to them, and use. This in turn shapes the identity of the community and links to the next proposition.

Fourth, the community's purpose is portrayed through its actions and the way the tools are designed and used. This is what gives them meaning and it stands for the development of affordable DIY tools that empower communities to collect data and which supports their role as active civic participants. The Public Lab also stands for the acknowledgement of expertise in everyone and that everyone has something to contribute.

Fifth, meanings and ethos shapes the community's internal and external relationships e.g. to new and existing members.

These initial propositions and concepts led to additional questions and concerns about DIY practice: the *potential* versus the promise of DIY practice and its impact – what is really

possible through DIY?; what sustains DIY communities?; and the commodification of DIY marketed as "bringing DIY electronics to the masses!" (Ceceri, 2012). The latter was noted in field notes as particularly problematic because it "objectifies the idea of 'power to the citizen' and people's desires (for empowerment, novelty, freedom) […] but [is] blind to questioning 'power for what and by which citizens?'" (Regalado & Kobayashi, 2013, n.p.). There were also questions about how the rhetoric and narrative of the DIY movement are constructed, shaped, and presented. I noted a *tension* between the way DIY is promoted on the one hand, with "enthusiastically overpowering (and uncritical) vocal support for activities revolving around citizen sensing, Hack Days, the Internet of Things, the Quantified Self, etc." (Regalado & Kobayashi, 2013) and on the other, by those who sought to put "the techniques and tools of information collection and sharing into the hands of communities [to] create local experts that are able to represent themselves, engage with scientific experts, and participate in the decisions which set environmental justice agendas in their communities" (Public Laboratory, 2011, p. 5). Both claimed to be part of the DIY culture, yet their cultures seemed to be guided by different purposes. These initial reflections led to questions about *practice*, *initiative-taking*, *empowerment*, and *questioning engagement*: "Do we need to stay in the fringes to not get absorbed by commodification of the DIY, Hacker, and Maker cultures? Or can we create our own alternative? If we do prototype alternatives will they have continuity and will they be 'immune' to [commodification]?" (Regalado & Kobayashi, 2013 n.p.).

The preliminary 'open coding' (see section 7.5, p.162) of interviews, essays, group discussions, community texts, and participant observations led to *generative questions* about practices of DIY in terms of culture, practices, tools, knowledge, and tensions. Specifically, it led to asking how communities and their practices are shaped and supported and how practice shapes 'doers' (or community organisers), practices being their interactions, experiences, and goals/aspirations, methods, and tools to enquire about and address issues around them. Through four years as participant observer in the Public Lab community, as local community organiser, and as participant in community (on- and off-line) gatherings, preliminary answers to the above questions began to emerge – both from my analysis and through discussions with the Public Lab community and others. Together, these concerns and questions provided a starting point for deeper analysis, theoretical sampling, and theory integration.

Box 2: A practical note for this and the next case study chapters

The analysis of this case follows the Grounded Theory approach (Figure 7.6) outlined in section 7.5 from sources of evidence presented in the background chapter. The first section presents the results from the first step in the analysis, namely, the comparative process and selection of research dimensions. This includes presentation of initial guiding concepts and propositions developed during the early stages of this research. The second section presents the results from 'theoretical sampling' of salient themes in the data. The third section focuses on the theoretical integration model, which brings together salient themes, and presents a schematised Grounded Theory for the processes shaping a community of DIY practice. I end with a discussion comparing and revising the preliminary concepts (hypothesis) with results from the in-depth analysis. The subsequent case studies follow the same layout.

The categories/themes used in the analysis are presented in *italics*. Additionally, quotes from sources of evidence are presented in the style [12:375], where the first number identifies the source and the second the quote number within that source in ATLAS.Ti. Some sources have more than one person 'speaking'. If so, the source number will be accompanied by a letter in

9.1.2 Dimensions and subdimensions

Table 9.1 lists the salient categories and subthemes generated during open coding of this case study. A complete list of the 200 codes identified for this case study can be found in Appendix B.1.

Community emerged as a main analysis category or dimension with several highly grounded and dense subdimensions. A dense subdimension is related to many other codes; density reveals the nature of the theme. For example, in Table 9.1 *values held* is grounded 55 times meaning it occurs 55 times in the data. It has a density of 50, meaning it is linked to 50 other themes, a wide range. On the other hand, *DIY tools*, another salient subdimension, was identified (grounded) 86 times in the data but it is more specifically linked to 17 other themes. Links are established through targeted theoretical sampling and generative questioning.

Table 9.1: Themes and subdimensions for community of practice case study

Category	Subdimension	Grounded	Density	Source
DIY	Tools	86	17	Data/Literature
	Defining the DIYer	18	3	Data
	Method	18	3	Data
Community	Culture and practices	57	48	Data
	Values held	55	50	Data
	Defining the community	53	46	Data
	Infrastructure	40	11	Data/Literature
	Commitment to the community	33	5	Data
	Growth	32	3	Data
	Diversity & complexity	31	4	Data/Literature
Working with people	Collaborative work	67	11	Data/Literature
	Building partnerships	23	3	Data
	Creating opportunities	19	3	Data
	Interconnectedness, complexity, parts of the whole	17	1	Data
Technologies	Use of software & hardware	62	18	Data/Literature
	Development of software & hardware	57	10	Data/Literature
	Interplay between tools & issues	29	3	Data
	Issues of technologies	22	2	Data/Literature
Communication	Creating the narrative of PL	53	46	Data/Literature
	Ways of telling the story /	14	1	Data / Coding paradigm
	Difficulty in explaining what PL does	13	2	Data
Science	Comparison to traditional	54	11	Data
	Grassroots	48	22	Data
	Issues of credibility/legitimacy	24	3	Data/Literature
Research	Issues / doing research	57	14	Data
	Role of researcher	14	2	Data
Access	Issues of	44	22	Data/Literature
Context	Environmental (justice) issues	41	16	Data
	Social justice	19	5	Data
Knowledge	Reflective thinking	43	17	Data
	Production of knowledge	36	12	Data/Literature
	Questioning what science/technology is	36	10	Data
Response	Appreciation	40	7	Data/Cases
	Critique	26	6	Data
Sharing	Data / techniques / knowledge	40	8	Data/Literature
	Meaning and values	22	3	Data
Engagement	Questioning engagement	37	14	Data
	Promoting engagement	29	4	Data
Goal	Address issue/problem	38	11	Data
Inclusion	Tactics or strategies for inclusion	36	6	Data/Coding paradigm
Exclusion	Instances of / conditions for	31	6	Data/Coding paradigm

Some of the categories used for coding are guided by the Grounded Theory coding paradigm (section 7.5, p.166) while others are concepts found in the literature. Other themes, such as *defining the DIYer* emerge entirely from the sources of evidence. In Table 9.1 the 'Source' column shows whether a theme is influenced by the 'literature', dictated by the 'coding paradigm' or if it was emergent from the data. Categories emerge from a collection of subdimensions, for example, *values held*, *culture and practices*, and *defining the community* were all related to *community* and were thus grouped accordingly. Other subdimensions emerged from generative questioning of existing subdimensions. For example, *creating opportunities for people* emerged from questioning *collaborative work*: what type of collaborative work is carried out, what does it do to people, and how is it manifested? Generative questioning and directed enquiry led to theoretical sampling and the development of an integrated theory for this case (section 9.6).

9.1.3 Theoretical sampling

Theoretical sampling involves focused questioning around salient categories with the purpose of confirming, disproving, or adapting them. Coding categories turn into themes and their subdimensions into subthemes as they become saturated i.e., questions are answered and relationships between them established. These relationships are determined by co-occurrence analysis using ATLAS.Ti – the results of which are presented at the beginning of each section of this analysis (e.g. Table 9.2). This layout is the same for the following case studies.

Sections 9.2 to 9.5 provide evidence for the relationships between the most grounded and dense subthemes in Table 9.1. The salient themes for practices of DIY enquiry in the Public Lab community are:

- *Community* in relation to community 'culture and practices', 'values', 'defining the community';
- *DIY tools* and its relation to 'use' and 'development' of software and hardware, 'actions' linked to use and development of tools;
- *Knowledge* in relation to 'reflective thinking' about the 'interplay between tools and issues', and 'production of knowledge' linked to 'questioning science/technology', issues of access and issues 'credibility'; and

- *Tensions*[22] in conceptions of inclusion and DIY.

I illustrate each of these next.

9.2 Theoretical sampling: Community

With 57 occurrences in the data (Table 9.2) *community culture and practices* emerges as one of the most salient themes along with *values held* and *collaborative work*. As part of the 'community' category, it is the most grounded and dense theme i.e., it is linked to the majority of other code categories (172 subthemes co-occur with it). In Table 9.2 the 'co-occurrence' column represents number of times a sub-theme co-occurs in the data with the salient theme; 'co-occurrence frequency' represents the frequency of occurrence of the subtheme within the main theme. For example, *values held* co-occurs 51% of the time that *community culture and practices* occurs.

As seen in Table 9.2 *community culture and practices* is associated to several subdimensions including *values held* and *defining the community*. It is also linked to 'communication' through the subtheme *creating the narrative of Public Lab* and 'working with people' through the subtheme *collaborative work*. The main *responses* associated with *community culture and practices* are *appreciation* and *openness*. It is also linked to the theme *learning* through the subtheme *being disposed to new ideas*. I discuss these in the following sections. It must be noted that relationships between these themes is networked; their representation on a table should not be interpreted as neat/linear.

Figure 9.3 shows the theme map for the category *community* in relation to the salient themes *culture*, *practices*, and *values* as well as *defining the community*, which encompass the other subthemes. The main subthemes discussed in this section appear in the blue boxes. The main insights from these subthemes are summarised in the white boxes.

[22] This theme emerges from deeper analysis in integration, rather than coding.

Table 9.2: Categories and their subdimensions (or subthemes) linked to the salient theme *Community culture and practices*.

Salient theme (grounded-ness)	Category	Subdimension	Co-occurrence	Co-occurrence frequency
Community culture & practices (57)	Community	Commitment to the community	44	0.47
		Values	39	0.51
		Defining the community	27	0.31
		Diversity & complexity	26	0.21
		Extending the community (allies)	21	0.20
		Interconnectedness of roles & actions	19	0.19
	Communication	Creating the narrative of PL	30	0.34
	Working with people	Collaborative work	63	0.46
	Response	Appreciation	35	0.32
		Openness	32	0.35
	Learning	Being dispose to new ideas	34	0.34
	Goal	Address issue/problem	31	0.28
	Access	Issues of access	34	0.26
	Inclusion	Strategies & tactics for inclusion	29	0.25
		Feeling included	22	0.22
	Sharing	Data / techniques / knowledge	32	0.24
	Engagement	Conceptualising agency	23	0.21
		Empowering actions	22	0.21
		Promoting engagement	20	0.18
		Taking initiative	19	0.19
	Knowledge	Reflective thinking	25	0.20
	Expertise	Informal (pointing out)	19	0.18

9.2.1 Community culture, practices, and values held

The theme *community culture and examples of practice* merges instances in the data reflecting or describing the culture of Public Lab and examples of practices of the group (i.e. ways of performing activities). It was found that these themes presented a very high co-occurrence; culture and practices are embedded in each other: "it is a culture of attribution and collaboration" [1:41] and "a culture of critical thinking and discourse" [6:8].

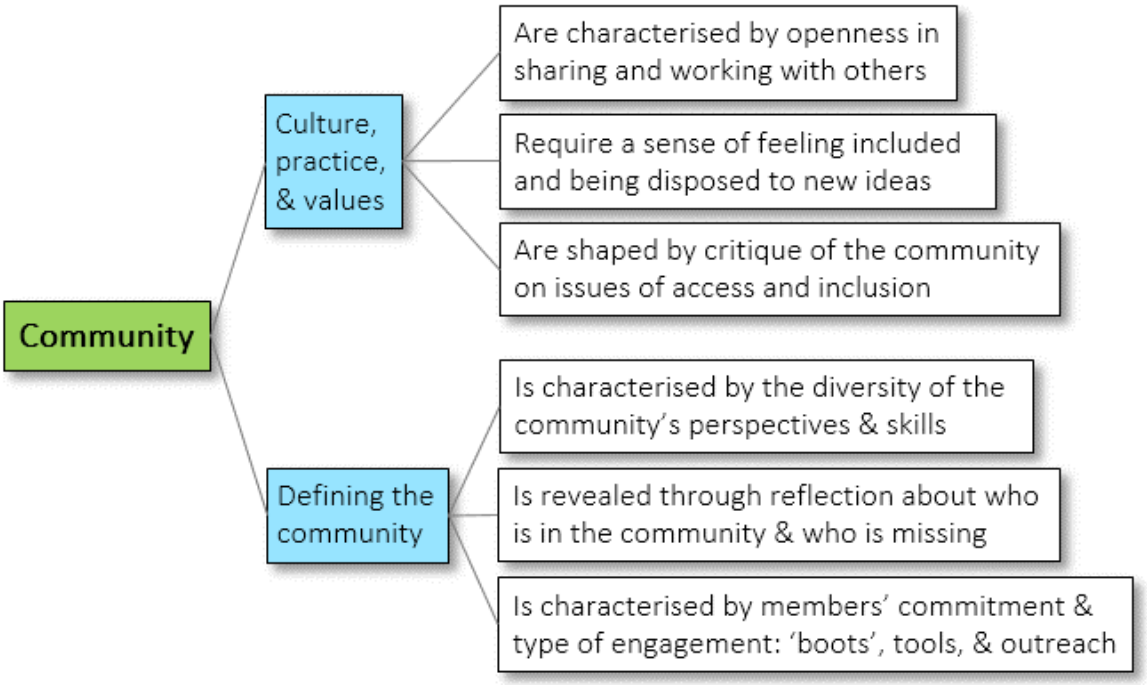


Figure 9.3: Theme map for 'community' – culture, practice, and definition of a community of DIY enquiry

Community culture/practice is most strongly revealed through *values held* and *commitment to the community*: "for me, it's been a year of being a bit of a Public Lab evangelist, and revelling in the fact that Public Lab has come up with this great approach, and one that generates such positive responses" [8*m*:53]. Community culture, practices, and values are reflected through *aspirations for the community* "we are building this community that has this set of norms of what is normal or acceptable, what is conventional to do, the habits that we build about how to attribute, how to take part in something [...] Because even though we have grown a lot we are still a very young community, so those things are still being worked out [1:33]". Culture, practices, and values are also revealed through the *narrative* and rhetoric employed by community members: "I've now travelled to [several countries] on behalf of Public Lab, and whenever I tell people about the way that Public Lab brings an 'open source, grassroots ethos' to environmental monitoring and environmental justice, the folks I'm talking to always seem to get the idea immediately and become really enthusiastic" [8*m*:55].

The most salient characteristic of community culture and practice is *openness*, *valued* by its members for a diversity of reasons:

> Symmetry of information as the exemplar of being open: what I know, you may learn, and what you know, I may learn [10*s*:174];

> Openness – to new members, to new ways of knowing, to experimentation even if it might result in failure [10*n*:138];
>
> Accessibility - making all aspects of documentation, development, community open and easily jump-inable [10*t*:187]; and
>
> The focus on open source that enables anyone with access to repurpose tools and methods [10*t*:91]

At both the individual and group levels, *openness* entails defining *values*, *sharing* ideas, and *being disposed to new ideas*. A community member exemplifies this:

> … just the fact that you get this group of people all in a room to talk about something and to share ideas- in that last session we were in, engineers who are talking mainly in acronyms about what they do, and not very legible for anyone else. Who knows if they had the same vision for inclusivity and collaborative, co-creation of science, or co-creation of knowledge that other people don't have. So even if we seem to meander a lot, there is a lot of different people being disposed to new ideas by other people in the community, and that is powerful no matter what happens. It can click and then suddenly you have these extremely strong allies [1:153].

Community culture also requires and is shaped by a *sense of feeling included*: "I value our ability to thoughtfully engage each other's opinions without fear that having a different opinion than the majority will result in being ejected from the group" [10*r*:169]. A salient response linked to community culture/practice and values is *appreciation* and it is accompanied by excitement and learning: "What happens when you bring a bunch of community scientist together? Well, for starters, they bring all of their monitoring tools to demo! [...] This provides an amazing opportunity to learn about the pros and cons of each as well as learn which ones would work best in each individual community" [9:1]. There is also a salient appreciation of the relationship between the community and the individuals and how this shapes identity and culture: "I think that the sense that you can do research and you can analyse water quality and you can do maps, what makes all of that stuff really meaningful is how that thing fits into the story of who we are or what our world is, or how we understand or negotiate our relationship with our surroundings" [2:83].

As the same time, community culture/practices are also revealed through (self) *critique of the community*. A salient critique is around *issues of access*. This theme is strongly associated with *production of knowledge* (9.4.2) and *questioning engagement*. For example, a member questions the purpose and scientific/research content of engagement:

> I don't mean for this to sound derogatory but, absent a meaningful research question or management question, it's all just a fun event and once the fun event part is done there's nothing else pulling you forward to do anything with the data that was extracted [...] There's a lot of excitement about the fact that it does get people engaged, but engaged for what?" [3:27]

Community critique is also about *instances of exclusion*. A community member exemplifies exclusion stemming from prerequisites for engagement:

> Every time you add a step, every time you add a requirement, every time you add knowledge that must be implicit or that people must have before they can participate, you are narrowing the field of people who can participate, and it is already- […] as much work as we do, […] it is already hard to participate in a lot of Public Lab projects [1:61].

Another strong aspect of community culture/practices and values held is *sharing data, techniques, and knowledge*. Sharing points to the value of *informal expertise* and the community *infrastructure* that sustains it: "I have learned through practice with Public Lab that it's an ongoing process. The technoscientific activity together with urban and environmental issues we are concerned with are the structure for building that social and political infrastructure that might yield change" [8*p*:100].

The analysis suggests that in addition to the openness, sharing, and inclusion, the community collectively values its *diversity*, its *potential*, and the *fun* environment and interactions, in particular at the face-to-face events. This is part of what defines the community discussed next.

9.2.2 Defining the community

> [T]he Public Lab are the founders and the staff and the organisers [and] all care really deeply about the things that they're doing and I feel that we're trying to be responsible about who we are and how we work with communities [2:43].

The analysis shows that the 'community' is defined by reflections on who is and is not in the community. It is also defined by the practices that members value and subscribe to, the challenges faced by the community, and the interactions between people with different interests and backgrounds.

Many of the sources of evidence point to a *diverse* community in terms of the practices that members bring, their interests, and personal goals. *Diversity* is described in terms of disciplinary background or occupation: "we are artists and designers, we have biologists and chemists, social scientists that are all working together to create the space that we're interacting in" [11:7]. There is also *diversity* of location (various regions in the U.S. and the world) and *diversity* in experience, described in terms of newness to the group. Linked to this, the community is also defined in terms of familiarity with the norms/practices of grassroots/DIY. It is also defined by the *diverse* activities and roles that community members take: fieldwork ["boots"], tool development, or outreach.

Engagement in and *commitment* to the community range from "a lot of us find ourselves really, really attached and committed to this community" [2:49] to those who consider themselves "to be at the far end of the low involvement branch" [3:119]. Yet, analysis revealed that members along the spectrum of engagement define the community similarly in terms of those who are not part of the community. For example, those who belong to "low income minority and environmental justice communities using the tools but [who] haven't located themselves within the Public Lab community" [3:18].

These examples point to a tension in community engagement and inclusion, which are discussed in 9.5. What is relevant here is that tensions in *diversity* of interests, goals, and approaches are the sources of *aspiration* and *challenge* that shape the community. For example, issues identified by community members are discussed at Barnraisings and conferences. A Public Lab founder defines the community in contrast to 'traditional' forms of 'participatory science':

> We also engaged critically with the notion of how public participation in science is supposed to happen […] in typical scenarios in citizen science, a scientist would say "I have a question and I'd like you, the community members, you, the people that are closer to that area to provide data for me" without the sense that science has a responsibility to provide data back in a format that was reusable and able to help people advocate to actionable objectives that they might have [11:12].

The community is characterised by these reflective process and interactions between people with different interests and backgrounds. It is through these interactions that people challenge each other and gain new insights about the community and their relationship to it: "the group of people that I encounter through Public Lab is quite diverse and enjoyable and there are some very smart people that challenge me and from not just this area but from all

over the US and various places around the world. So it is wonderful" [4:8]. Interactions within the community require *being disposed to new ideas*, *collaborative work*, and *extending the community*. They also highlight the need to reach out to "organisations, communities and agencies […] and tighten existing relations" [10:8;10:104]. Integral to this work are DIY tools, discussed next.

9.3 Theoretical sampling: DIY tools

DIY tools are predominantly described in terms on their *use* and their *development*. As seen in Table 9.3 *DIY tools* correlate strongly with a *local context* and *environmental issues*. The *use* of *DIY tools* tends to be highly localised in context and knowledge. Both the *use* and *development* of tools and are strongly correlated to *monitoring*, *DIY sensing*, and *advocacy*. However, it is the *development* of tools which is strongly correlated with the *culture/practices* and *values held* by the community. Figure 9.4 illustrates the main themes and insights from this analysis.

9.3.1 Use of DIY tools

DIY tools include hardware, such as aerial mapping kits and spectrometers, and online infrastructure such as the Public Lab website and the map-making platform MapKnitter.org. The analysis reveals that *DIY tools* are mostly used in local contexts and mainly within environmental issues framed as 'environmental justice' such as monitoring agriculture using DIY NIR cameras and aerial mapping for environmental conservation.

Tools are at the heart of Public Lab practice and ethos. Thus, tool *use* correlates with *reason for engagement* and both are diverse in nature. A community member explains: "the tools are this bridge between the environment and the data collection [but] for every person that likes this stuff there's somebody who would really rather just look at the pictures or some numbers or analyse some charts, and on the other side there's somebody who really just wants to go outside and fly a kite" [2:115].

Table 9.3: Categories and their subdimensions (or subthemes) linked to the salient theme *DIY tools*.

Salient theme (grounded-ness)	Category	Subdimension	Co-occurrence	Co-occurrence frequency
DIY tools (86)	Technologies	Use of hardware & software	53	0.53
		Development of hardware & software	29	0.24
		Interplay between tools & issues	9	0.08
	Context	Local	20	0.21
		Environmental issues	23	0.18
	Science	Grassroots	23	0.18
	Action	Monitoring	17	0.17
		DIY sensing	16	0.16
		Advocacy	14	0.15
		Investigation	12	0.12
	DIY	Method	14	0.16
	Knowledge	Local knowledge	13	0.14
		Production of knowledge	17	0.13
	Engagement	Conditions for engagement	16	0.13
	Practice	Innovation in approach / techs	13	0.13
	Goal	Address issue/problem	14	0.12

Analysis also reveals that while DIY tool *use* draws from and builds local *knowledge* (section 9.4.2, p.213) it also points to *instances of exclusion* and *limits to participation*. For example, a member's critique of Public Lab's claim to inclusion points to limits to participation in tool use and understanding:

> Interviewer: Do you think that there's some basic level of skill or mastery required to engage with Public Lab?
>
> Respondent: Yes absolutely, I don't think I have half of it to tell you the truth! I've successfully balloon-mapped. I struggle to kite-map. Any of the other tools… I've not taken apart a digital camera and I don't know what to do with a spectrometer. And I'm interestingly realising that a lot of other people here don't know what to do with the spectrometer right now. So I think that despite the rhetoric of "anybody can pick this up and do this" I don't know if it's actually true [3:24].

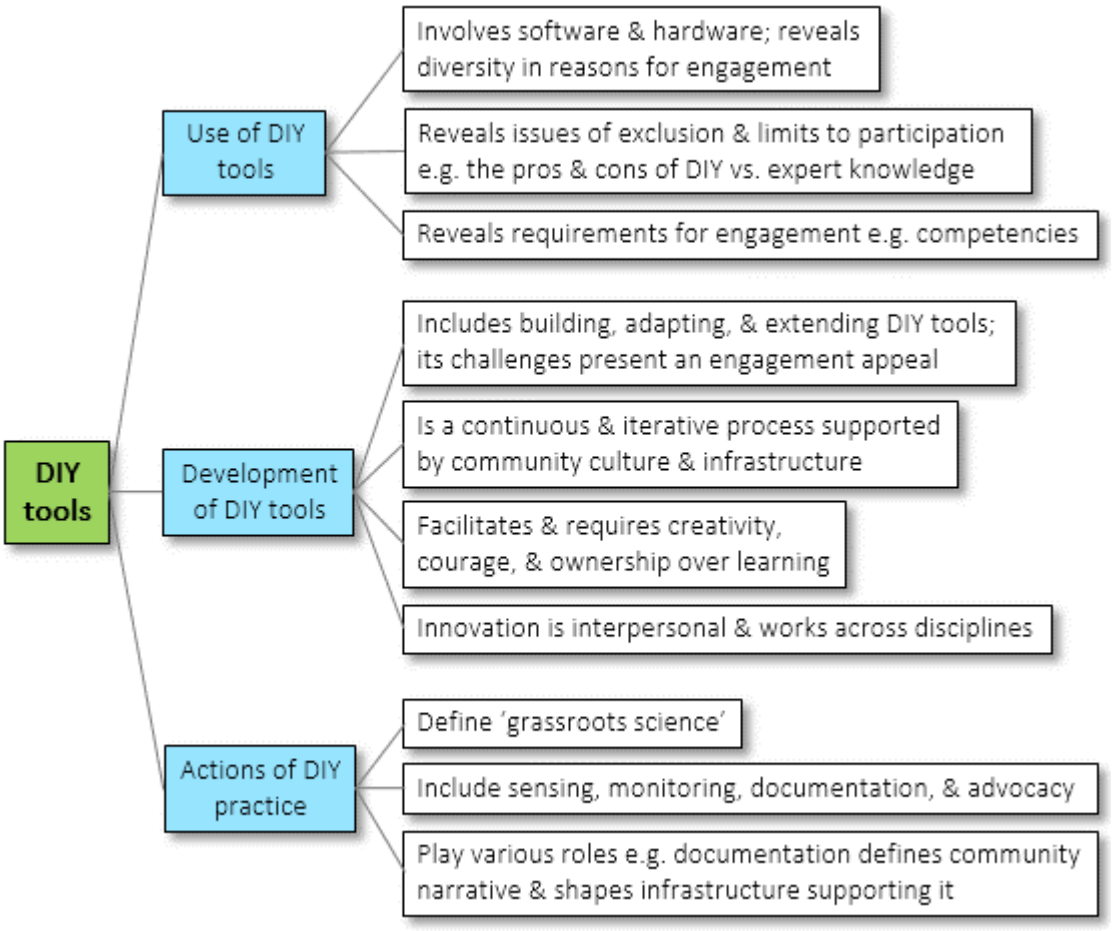


Figure 9.4: Theme map for 'DIY tools' in a community of DIY enquiry

The requirements or "competencies" needed to engage with tools are commonly discussed in the community and include: "competencies necessary to participate, competence in building tools, competence in using tools, competence in knowing why you'd want to use a tool, or where you're going to want to use it" [15:1]. These requirements are often conceptualised as a step-process ranging from very little to strong commitment:

> [W]ith a fairly small amount of reading to understand how to set it up [...] that is probably the bottom rung, then go on up from there. So it takes a commitment to learn some basic things and having a little bit of manual dexterity [4:32].

> With Public Lab equipment, it is quite easy to collect a thousand map photos in an afternoon and have fun doing it. The fun part ends there for most people, and 90% of the work remains to be done. Sorting and selecting images is tedious and requires facility with software and a big hard drive. Stitching in Mapknitter is slow and requires patience, practice, and attention to detail. Large projects require an alternative to Mapknitter (e.g., Photoshop) which have fiscal, hardware, and training requirements [12:1].

Concerns by community members about the limitations of DIY tool use revolve around issues of *access* to knowledge. For example a community member contrasts the knowledge required to address real-world issues versus the set-back from trying to acquire that knowledge through trial and error:

> I think people can spend a while looking at the wrong things, especially without a more formal education where you're forced to just build up a lot of information over the course of however many years. […] The danger with some of our stuff, I think the danger of also just saying that DIY science is for everybody and anybody can do anything is that you run the risk of letting people spend a lot of time looking at things that a more informed person might not have to worry about [2:67].

This highlights the pros and cons of DIY versus 'expert knowledge', which is linked to a *tension* in the way DIY *use* is conceptualised: DIY as a means to addressing a social/environmental issue that is time-sensitive or DIY as an end in itself to e.g. gain *ownership over learning* or feel satisfaction about getting a tool to work. This is discussed further in section 9.5 (p.215).

Although not salient themes, other *uses* of DIY tools include outreach and education. Community organisers build capacity (in themselves and others) by teaching about the community's approaches and tools. They do this through hands on activities (e.g. workshops) and by *documenting* and producing open source how-to materials (Figure 9.5).

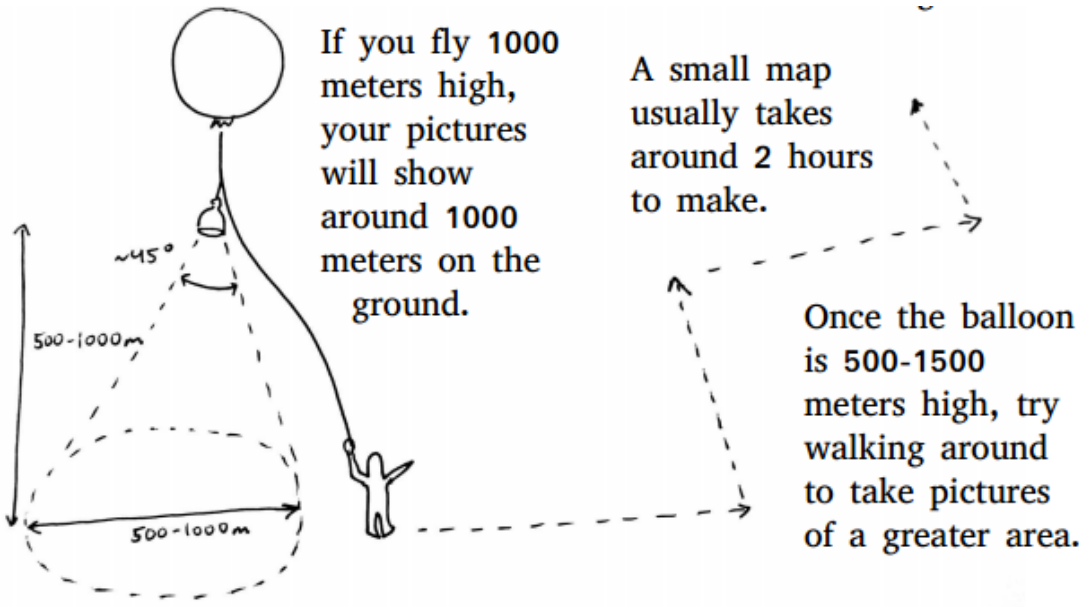


Figure 9.5: Extract from a how-to guide on balloon-mapping [Source: Public Lab].

9.3.2 Development of DIY tools

The *development* of *DIY tools* encompasses the process of building, adapting, and extending DIY tools, for example, designing and testing components and calibrating them. Community discussions about design and techniques of tool development are also part of this theme. Notably, there are more discussions about tool *development* and design than of tool *use* in the sources of evidence. Hence, the *development* of *DIY tools* appears strongly correlated to the culture, practices, and values of the community. It is also strongly correlated to conceptions of *innovation*.

The development of tools is described as a range from "very simple solutions to some problems" to "more complex than a bottle and rubber bands" [2:25] (Figure 9.6).

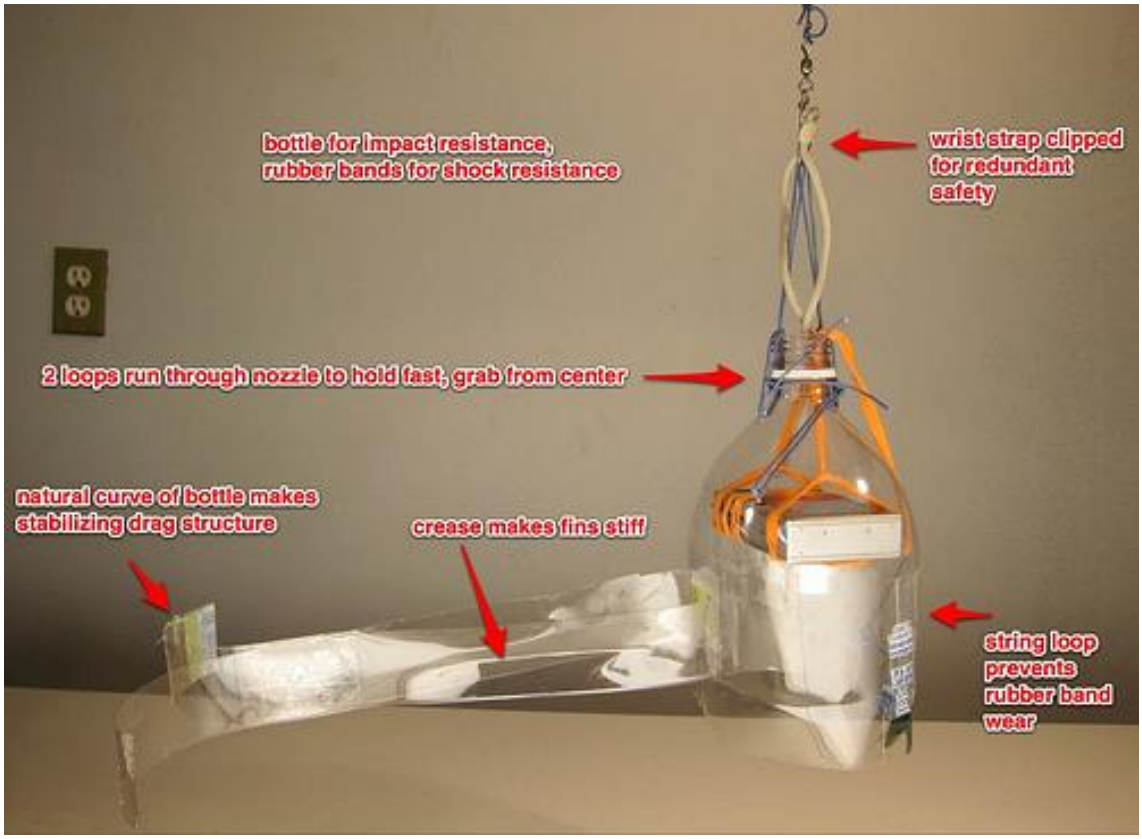


Figure 9.6: Tool development technique: how-to guide for making a camera rig from PET bottle [Source: Public Lab].

Development is also seen as an ongoing process: "Although this tool has been in use for many years, components of the kit – kite and balloon design, the rig, the camera – continue to evolve as they are adopted in new places and adapted for new purposes" [6:3]. Therefore,

there is a strong correlation between *tool development* and *engagement*. However, as noted in tool *use*, as more commitment is demanded, the smaller the proportion of community members engaged: "And there are precious few people at the latter stages […] maybe a dozen people who know what they are doing in DIY spectroscopy, and are chipping away at the future technical challenges- the scientific research challenges" [1:150].

The analysis reveals that engagement in DIY tool *development* is appealing to some because it presents a *challenge*: "I spent hours figuring out how to make it work properly [...] I was excited to be able to build essentially whatever I wanted to within certain laws of time constraints and material constraints" [4:28]. It was noted that the rigorous design process requires "so many things to work correctly for it to succeed as a project". However, this ambition of succeeding is what motivates some members to not merely go for "the lowest hanging fruit" [1:105]. Ideologically, it is considered a *powerful* action to be able to take something rare or "obscure", unattainable, and expensive and "just make it ourselves out of paper, you know, like that's something that's powerful" [1:105]. Tool *development* is linked not only to 'making' but also to having *ownership over learning*: "I think some of us, we want to make things, but we also want to understand the tools that we're using to measure our understanding of the environment" [2:108]. Thus, making the tools is also seen as part of a bigger cycle of engagement in addressing local issues:

> [W]e encourage people to engage along the entire research continuum- from asking questions, identifying what the problem or issue in your neighbourhood might be, to looking at the landscape of tools that might be available to do monitoring and if they aren't available then *make* them– so building the hardware tools, creating the software analysis platforms, going out and doing the data collection, processing, interpreting, analysing data and then working towards drawing conclusions that will help lead towards actionable goals [11:13].

DIY tool *development* engages *creativity*, problem solving, and *courage*. It is about imagining solutions combined with an iterative process of trial and error. It is these various iterations and dimensions of the DIY 'journey' "over time" that are the meaningful part of DIY practice in this community; the journey shapes the ethos:

> [F]ailure is a really interesting and important and meaningful part of the process and I wish that everyone would write about their failures in all of the research notes all of the time. I would really love to see those because I think they're really interesting and I think that that is as a productive tool for learning as reading about the right way to do something [2:83].

The innovative process in *development* also involves working across boundaries of space and cross-cutting applications. For example, taking one DIY technique developed in one place, applying it to a different problem elsewhere, and *working collaboratively* to accomplish it. This is in part facilitated by their online infrastructure but also because 'different versions of tools' that are valued and encouraged (Figure 9.7).

Both the *development* and *use* of tools are linked to specific actions ranging from monitoring to advocacy, which make up the practice of *grassroots science*. I explain these next.

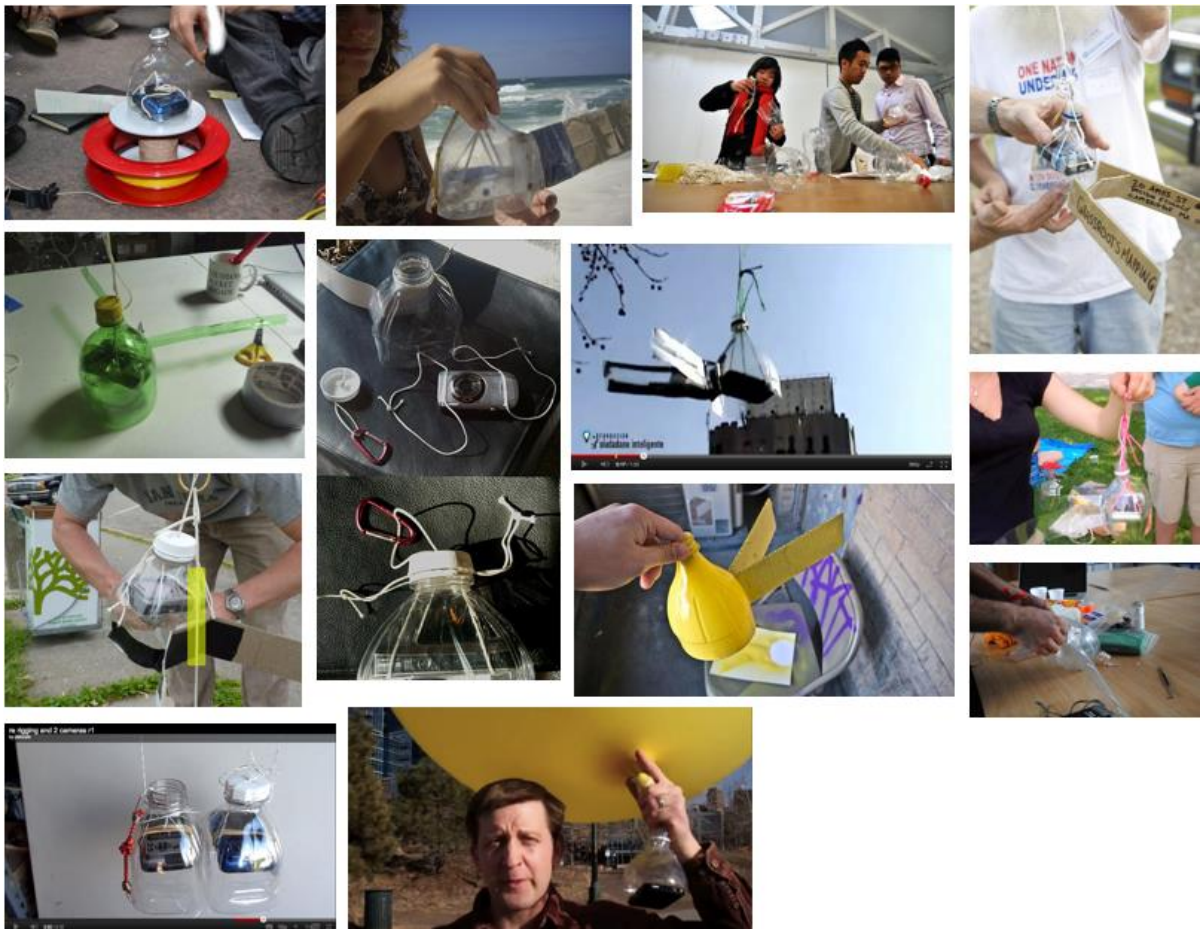


Figure 9.7: Multiple versions of PET bottle camera rigs – reflecting local resources and needs [Source: Public Lab].

9.3.3 The 'actions' of DIY practice

The simplest conception of *grassroots science* is "to create, collect, and share data that communities can use" and to develop initiatives that "support work across the 'full data lifecycle' from problem identification to data collection to using the data for action" [7:9].

Grassroots science reflects the ethos and aspirations of the community: "a place where people can collectively learn, build, and create together in a way that recognises expertise within each individual" [8*a*:4] and where "questions about how we could identify oil on the spot or how we could reframe the necessity of expensive lab equipment to do our own monitoring" [8*a*:9] can be explored. Analysis points to strong links between *grassroots science* and reaching "actionable goals". The most salient *actions* in grassroots science identified through the analysis are *sensing*, *monitoring*, *investigation*, *documentation*, and *advocacy*.

Sensing is characterised by the specific use of *DIY tools* in detection, such as "measuring and detecting particulate matter using sensing devices around frack sand mining sites" [7:10] or "developing strategies for sensing natural gas extraction by leveraging more mature Public Lab tools [such as] aerial maps" [6:4].

Monitoring activities involve keeping track of issues over a period of time such as "monitor[ing] invasive aquatic plant removal using DIY multispectral aerial photography" [8*g*:46] or continued "wetlands monitoring along the Gulf Coast after the BP oil spill" [6:1].

Documentation of site-specific work ranges from recording progress of initiatives (e.g. habitat restauration) to citizen participation in these efforts. However, the analysis reveals that other dimensions of documentation also link to *production of knowledge*, such as "how-to guides for making and customising tools for enquiry, and methods for conducting rigorous investigations, which are in turn documented on our site and in hard copy at research centres" [6:9]. These "function as civic information: visually accessible and distributable in standard formats" [6:9]. *Documentation* also links back to the *open source* ethos of the community, which in turn shapes the *infrastructure* that supports it:

> The Public Laboratory website is where our community develops open-source documentation and literature around our DIY civic science research. Documentation has dual functions- first, to create a geographically diverse network of people engaged in civic science activities, and second- because of the Share-Alike license under which tools are developed, to ensure that new research based on Public Lab tools will remain open source, and be contributed back to the Public Lab community [6:5].

Documentation contributes to continuity and as a *narrative*, it is a way of telling the story of 'place':

> The kite and balloon photographs we've taken of the disintegrating rim of Barataria Bay is an important part of documenting BP's aggravation of the legacy of industrial

> damages to our great North American delta. With these images, we can broaden and deepen the story of our home, the great estuary that keeps us sheltered from coastal storms and the great engine of life that keeps on producing so many birds, fish, and mammals [8*o*:76].

Advocacy is linked to production of evidence to raise awareness and to *hold polluters accountable*, as "most of us are interested in something happening as a result of the research we're doing either, advocating for something to get cleaned up or to get people aware of and engaged in talking about an issue [2:114].

These various dimensions of *grassroots science* point to a deeper relationship between *DIY tools* and the many issues to which *actions* are linked. Questions about these relationships arise through community members' reflective thinking, explored next.

9.4 Theoretical sampling: Knowledge

Reflective thinking and *knowledge production* emerge at the most salient themes in the category *knowledge*. Their salient subdimensions (Table 9.4) discussed here include *exclusion*, *questioning engagement* and *expertise*, and issues of *access* and *credibility*. Figure 9.8 illustrates the insights from these themes' analysis.

9.4.1 Reflective thinking and interplay between tools and issues

Reflective thinking is an integral part of the community's culture of enquiry. It is facilitated by discussion and takes place online (via mailing lists, the Public Lab platforms, etc.) and off-line (at Barnraisings, other events, and through interviews). Reflective thinking focuses on practice, engagement, and purpose of actions:

> I value questioning the 'who' and 'why' of environmental science: exploring 'for whom' science is done, 'by whom' and towards what end – and exploring these questions through action [10*p*:158]

Table 9.4: Categories and their subdimensions (or subthemes) linked to the salient themes *reflective thinking* and *production of knowledge*.

Salient theme (groundedness	Category	Subdimension	Co-occurrence	Co-occurrence
Reflective thinking (40)	Community	Culture & practices	25	0.20
		Values held	23	0.16
		Defining the community	20	0.12
	Knowledge	Questioning what science/technology is	11	0.16
		Production of knowledge	12	0.12
	Exclusion	Instances / conditions for	14	0.13
	Expertise	Questioning expertise	9	0.13
	Technologies	Discussion about technologies	10	0.13
	Engagement	Questioning engagement	9	0.12
Production of knowledge (34)	Knowledge	Issues of knowledge	17	0.24
		Questioning what science/technology is	16	0.22
	Community	Values held	26	0.19
		Culture & practices	25	0.19
		Defining the community	22	0.15
	Communicatio	Creating the narrative of PL	25	0.18
	Access	Issues of access	16	0.17
	Research	Issues of / doing	15	0.17
	Technologies	Use of software / hardware	19	0.17
	Action	Monitoring	13	0.16
		DIY sensing	10	0.14
	Science	Grassroots	12	0.14
		Issues of credibility / legitimacy	11	0.15

Reflective thinking shapes and is shaped by the culture and ethos of the community. For example, as members question the purpose of actions, reflective thinking reveals *values* grounded on *access* and *addressing* real-world issues. A community member reflects on the *interconnectedness between roles and actions* of the community:

> …why do we build tools and try to do research with those tools? Because that's hard, right? The tools aren't done yet, most of them, right? So how do we get credibility for tools that aren't done yet? But how do we get people using tools if we can't invent cheaper tools and if we don't have a group of people who are familiar with how they work, because they weren't involved in building them. How do we have tools that are

appropriate to answer the questions we need if we don't have people who have those problems helping to frame the questions that the tools are supposed to answer? [1:82]

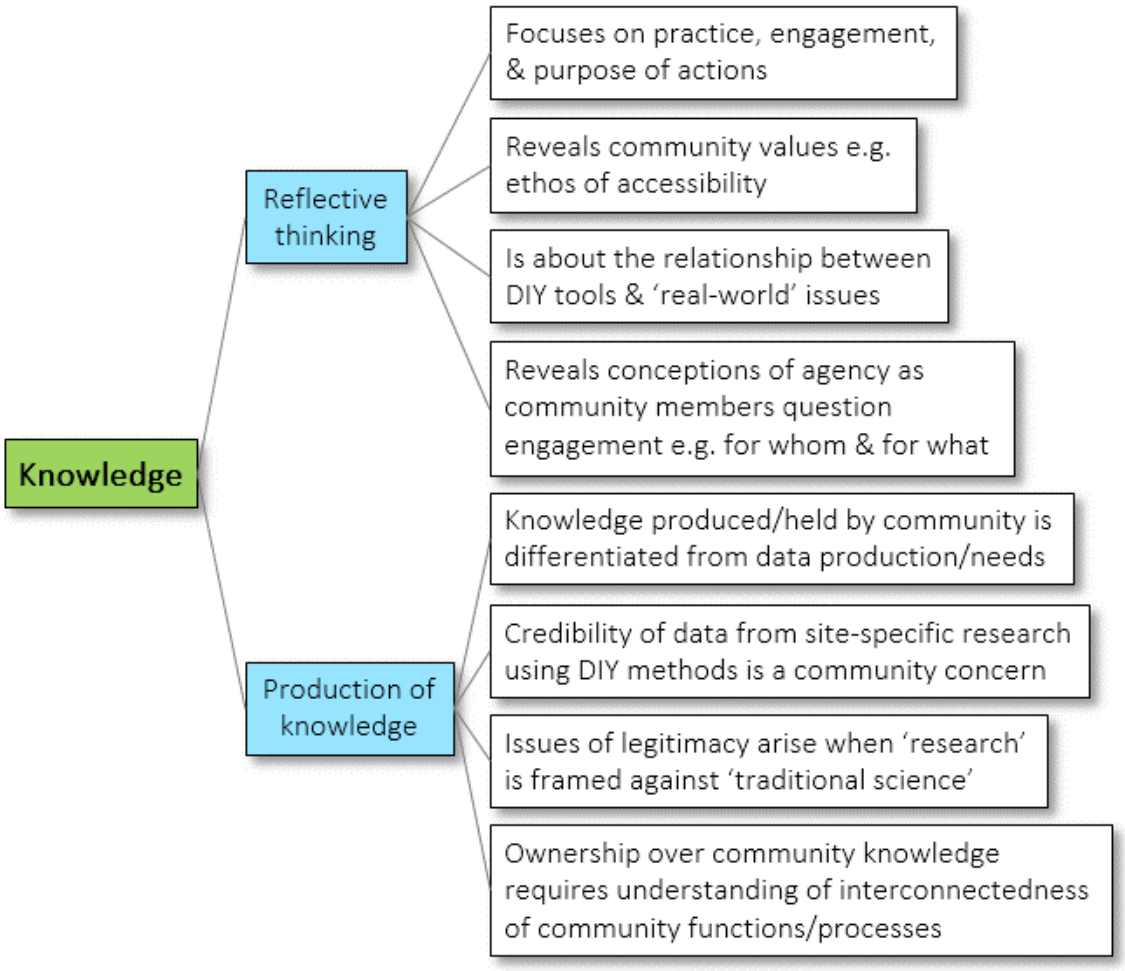


Figure 9.8: Theme map for the coding category 'Knowledge' in a community of DIY practice

Reflective thinking reveals concerns for whose values are reflected and embedded in design of tools?' at interplay with the need for an initial design that kickstarts the process of engagement in the first place. Reflective thinking further reveals a tension in the framing of DIY when referring to 'real-world needs' versus motivational 'challenges'; the framing of DIY tools also changes. For example, the use of 'half-works' versus 'half-broken': when doing "outreach to tech developers- when you show someone something that half works, it invites people who know- who are into making things work- to get involved […] but then we compared that to- well, does passing around half-broken things work as well when we're relating with communities who have an urgent question they just want to answer?" [16:4]. This distinction in framing is explored further in section 9.5 (p.215). Relevant here is that the

relationship between tools and issues exemplified above points to reflections on *conceptions of agency* about who is feeling empowered and to what extent:

> '[F]iguring out to what extent anyone's been empowered', I think is something that I wonder about, and I think a lot of people are […] thinking about either who sticks around and engages with Public Lab stuff going forward, or who takes from their interaction with the Public Lab a sense that they have an empowerment to look into their problems and make sense of them on their own, and advocate based on what they understand about what it is that they're doing [2:64].

All these conceptions point to factors enabling *action* (e.g. courage and working together), the community's relationship to technologies (e.g. co-design), and a sense of *responsibility* towards those it engages with (e.g. seeking to understand level of impact).

Linked to *agency*, reflective thinking is also about *questioning engagement* – the "'by whom' and towards what end" in the first quote of this section. This further reveals that *issues of inclusion* are of prominent concern to the community, for example, as in section 9.2.2 (p.199), what does the community look like and who is missing. A community member reflects on community management and organisation:

> I'm interested to know who's built into our systems to *be* included and who isn't because there are definitely people that aren't [...] in a lot of ways the Public Lab looks really different than the communities that we work with and that we tend to mobilise with around a problem but we don't necessarily- they don't somehow end up in our group of organisers or continuing on as active members of the organisation itself [2:17; 2:46].

Reflections that *question engagement* reveal issues of *empowerment* linked to *agency* as seen above. They also reveal questions about *empowerment* linked to tool *use*:

> I'd like to know who the users are and whether or not it really is being adopted by environmental communities or trying to make a case about what's happening in their places – or not. If most of the people buying these kits are using them in their projects or just for fun or whatever or if they're professional researchers, if they're just looking for cheaper tools [3:67].

Other themes of reflective thinking are issues of *access* in terms of privilege based on race and gender and interaction with authorities. Reflections on matters of practice, engagement, and tools is central to the community and go hand in with both *production* and *questioning* of *knowledge* discussed next.

9.4.2 Production of knowledge

Production of knowledge in the Public Lab community is both an object of reflection and an integral aspect of community's culture. Predominantly revealed in tacit and documented forms, its salient themes include issues of *credibility*, doing/defining *research*, and *ownership* over data/work (Figure 9.8).

Community members identify a difference between knowledge and *data*; the 'weight' of the latter in addressing real-world issues is commonly discussed. This in turn points to underlying concerns about the nature and the *credibility* of knowledge held or produced by the community:

> [M]aybe a lot of people have knowledge, but data is somehow perceived as more authoritarian and is more systematic or seems to be more systematic. It's like more machine-readable. It's not necessarily the case, but if you talk to people around here, they've a lot of knowledge about pollution's effects, right? But some of them maybe don't feel like they have a lot of data about it [1:123].

Analysis also reveals that *credibility* associated with "site-specific research" is linked to purpose, such as seeking actionable goals (e.g. DIY enquiry to hold polluters accountable). Here *credibility/legitimacy* are situated in relation to a goal by the use of a frame of reference. This is explored further in section 9.5 (p.215) but here it helps to reveal the nature of *knowledge production*. For example, a community member critically frames the tensions in grassroots science practice in relation to canonical science:

> [I]t's been interesting to see the extent to which some folks in the community grab for the legitimacy of the word 'science' at the same time that they want to deconstruct what that word is and what it means to do it and I think it's creating a bit of a chicken and egg situation for the organisation and its community is trying to figure out what it does because every time it reaches for the legitimacy of "we do science" it then takes three steps back by saying, "but we don't do it that way; but we still do science because who are you to tell me what science is" [3:6].

A community member exemplifies this tension:

> Respondent: […] we should figure out how to get the scientists to embrace this sort of research.
>
> Interviewer: Do you think it would require some change from the Public Lab community to be able to invite professional scientists?

> Respondent: I guess I look at it the other way. They need to change, we don't need to. That is the easy answer but obviously that is not a good answer […] we need to prove to them that we are a valid pursuit [4:14].

With 'traditional science' as a frame of reference, *research* as a community practice also comes into critical scrutiny by the members:

> We need defining what we mean by science and defining what we mean by research and defining what we mean by a Public Lab project. […] so far things like research notes pretty much any level of participation or expertise is pretty much applauded and that's great but it doesn't make all the research notes research" [2:19].

> A stack of research notes is not a research product- it's what goes into making one. That's a big part of what's missing from any effort Public Lab might have toward knowledge production and it's funny because actually it makes it less- it makes the results less accessible, less open [3:106].

The frame of reference is itself not questioned, but the tensions created from its use are evident to some community members. For example, issues of perceived fragmentation in the community's practice are identified as a tension between the different scales at which Public Lab initiatives operate. This in turn leads to questions about how different aspects of *practice* fit together.

> …if there are two different groups of people- wearing boots [i.e. doing site-research] or making tools, is it just that some of the same people take on those roles at different times? And I've been wondering, is it really the speed of the different types of activities that keep those groups fragmented, and the different modes of communication used by those two groups that also keep them fragmented? [16:5]

In seeking to understand how different parts of DIY practice work together, the community also seeks to gain *ownership* over that practice and culture. For example, part of the process of *production of knowledge* is understanding the development trajectory of a tool within the 'scientific process':

> We discussed about how our technology interacts with our scientific process- of how do we understand when we're doing something right? Are we having a software bug, a hardware bug, or are we getting the science wrong? And being able to troubleshoot through those issues, especially with new technologies, or with technologies that are just in development. And then, trying to understand what's the trajectory of a development or a scientific process, and where have things been, where is it going, and where do I fit? [15:4]

The continuous reflective thinking that takes place on- and off-line in the community guides *production of knowledge* and *initiative-taking* in terms of both community management and defining *grassroots science* practices. For example, the above reflections on fragmentation led the group do extensive assessment and re-designing of the Public Lab website, which now includes activity grids that connect research notes to tools and issues while also tracking related updates and questions.

Additionally, in response to issues such as lack of credibility or fragmentation as seen above, community members have identified practice-based needs:

> What I proposed was that research has to have methodology [...] some kind of analysis of the information that you're finding […] unless I can connect to the tool that tells me what all that stuff is and maybe some sense of what things should or shouldn't be there, or what things are or aren't problematic- without the ability to contextualise it and a larger understanding of that thing, then you're going to be a little bit stuck and limited, and reduced to that person who's just sending data back to the mothership without continued investment or ownership of that work" [2:126; 2:138].

As the community seeks to understand how its different practices come together it also seeks to uphold its commitment to *values* of *access* and *inclusion*. These are the sources of tension discussed next.

9.5 The nature of tensions in a community of DIY practice

Tensions in the community's rhetoric and practice stems from the continuous struggle to define itself: "on both ends of that spectrum people are trying to figure out where the walls are" [2:120], specifically, with regards to *inclusion*. Tensions also stem from the use of 'science' as a frame of reference to define their grassroots and DIY practices.

9.5.1 Perceptions of inclusion

The analysis reveals that on the one hand, members feel there is something for everyone in the community: "there is very little that is formal in this organisation. So we are free to drift off in any direction we want to go" [4:41]. At the same time, it is acknowledged that "being all things to all people is not a practical mission for any kind of organisation" [2:91].

For example, Public Lab is described as "finding the abilities of each and every one who's interested to contribute and take part" [10*a*:5]. Hence, while some members perceive and value that the community has "a tool-centred approach, rather than a practice-centred approach [which] makes it easier to engage and adapt to your own circumstances" [10*g*:70], others value it's practice-based approach: "it's people-centred... technology is a way to get to and facilitate human interactions, not the end goal" [10*b*:17].

At the same time this vision of openness and inclusion contrasts the various realities that the organisation faces: "the work that we do- technology, community organising, and then the environmental issues that we're working on all move at vastly different paces and then you add funders on top of it, who want you to get stuff done, and then you are in a very complex place" [11:31]. Highlighting the value of diversity, and linking to the previous case themes, these discrepancies inspire reflective thinking and motivate continued engagement:

> What does a meaningful grassroots monitoring effort look like? When data analysis is very complex and lot of background knowledge is required for interpretation, how do we best support a truly participatory process that involves everyone? How do we transition from a DIY approach to a DIT (do it together) approach that brings everyone to the table without reinforcing unhelpful hierarchies in authority? These are the big question for me [8*m*:58].

Not surprisingly, tensions are what inspires the members and founders of Public Lab to continue building and improving it; as with DIY tools, it is the challenge of making things work (e.g. justice and equality) that invites (continued) engagement.

9.5.2 DIY as a means, DIY as an end

Whether it is in reference to a tool or a practice, the conceptualisation and/or attitude toward DIY is dependent on its framing (i.e. its symbolism): DIY as a means to achieve something (e.g. doing environmental monitoring for advocacy) or an end in itself (e.g. making a spectrometer because 'we can'). A community member illustrates the distinction: "A tool might be seen by one member to forward a goal. Another member might see that tool as a goal worthy of its own merit" [10*s*:178].

As a means to achieve "actionable goals" the framing for DIY draws from traditional science for credibility. The focus is mostly on reliability to, for example, obtain "facts that are admissible in court" [3:44] when there are urgent pressing questions.

As an end, it is mostly framed in terms of self-reliance and creativity; its potential is highlighted as it can "inspire a kind of […] MacGuyver imaginary that reawakens a sense of creativity and changing how one can know about the world, and just opening up possibility" [16:5].

The distinction between means and ends is not clear-cut nor explicit for the community, and neither are means and ends mutually exclusive. However, the difference creates a tension in expectations:

> …Public Lab is involved in both site-specific around environmental monitoring *and* the invention of tools. Those two parts are something that we don't essentially talk about in a lot of our outreach materials. Sometimes we'll say "investigating environmental issues and also make sure that people can do that affordably" or something. […] I'm hearing at the conference, or the Barnraising now, that we have to distinguish whatever we're doing, whenever we're reading a research note, or posting a Wiki page, or teaching someone how to do something, we have to be upfront and say "This is partially to make sure this tool works" or, "this is a tool that we're pretty sure does work and we're solving a problem with it". But the two overlap a lot, there's a big grey zone [1:178]

Focusing on the 'framing' reveals the position/attitude taken on DIY. For example, while some community members focus on the tools and what you can do with them, others frame them in terms of validity claims:

> …the spectrometer, for example, which is still in prototype development, it's benchmarking needs to happen in order to make any claim with its valid data that's coming out of it. So there's this iterative "does it work?" question that's happening there [3:27].

Here the tool 'development' journey is not central, whereas another member focuses on defining agency in this trajectory:

> I've started to use 'techniques' instead of 'tools' to talk about Public Lab things because I think tools […] implies a finished thing. You're like, "Hey, use this hammer," or like, "Hey, use this prototype, which is maybe going to help you put nails into things. But probably not, probably you're going to have to improve it and publish those results online so that other people can…" you know, but yes, I think that […] when you're talking about a technique to do something, I think it's maybe less technocentric than

> talking about a tool. A tool embodies a lot of things, a technique is maybe something that a person does […] maybe I'm just imagining these fine distinctions, but I do think that language that emphasises people's ability to perform a series of steps to achieve something is preferable to our goals than a magical tool that accomplishes things for you [1:138].

The understanding of DIY, whether it is tool-, practice-, outreach-centred, or a blend, necessitates an understanding of its framing because, as exemplified above, it reveals underlying goals and anchors its meanings. It enables placing the individual, the techniques, and the community along a continuum of a DIY journey, which in turn gives DIY practice clarity and acknowledgement. As Wegner (2002) notes, common language and understanding helps to establish and legitimise a community of practice.

9.6 Integration and core concepts

Figures 9.9 and 9.10 illustrate the Grounded Theory for a community of DIY practice. I would like to emphasise that, grounded on the data for this case study, this theory is specific to the phenomena in the Public Lab community through my experiences and observations. Nevertheless, the *substantive theory* (section 7.5, p. 167) produced intends to account for as much *variation* in the data.

The process of integration is aided by the construction of network diagrams (sampled in Appendix A.5) that further ground and saturate codes by establishing links between them. These links are established through iterative questioning (e.g. "what is the relationship between these themes in this situation", "what does this quote say about this and that theme", or "when is this not the case?" Answers to these questions are reduced to a simple relation that then guides the integration model. These are illustrated in the following theoretical model.

The Grounded Theory of the Public Lab as community of DIY practice is illustrated in two parts: the positioning of *culture and practice*, and a zooming in into it, its salient characteristics and its interplay with *tensions* and conditions/enablers.

Looking at the first part of this theory, Figure 9.9, *community culture/practice* is embedded in the interactions, as initially proposed but not only internally/externally between people but also meanings and artefacts (tools, infrastructure, rhetoric, etc.). Culture, practice, and

interactions are in turn embedded in the various framings of the community – either external or internal to it. Culture, practice, interactions and framings are fluid (and are thus illustrated with fuzzy edges) and are themselves influenced by various dynamic *conditions* (represented by dotted lines). This model proposes that all Public Lab interactions, culture, and practices are framed or contextualised and that that framing draws from certain factors internal and external to the community.

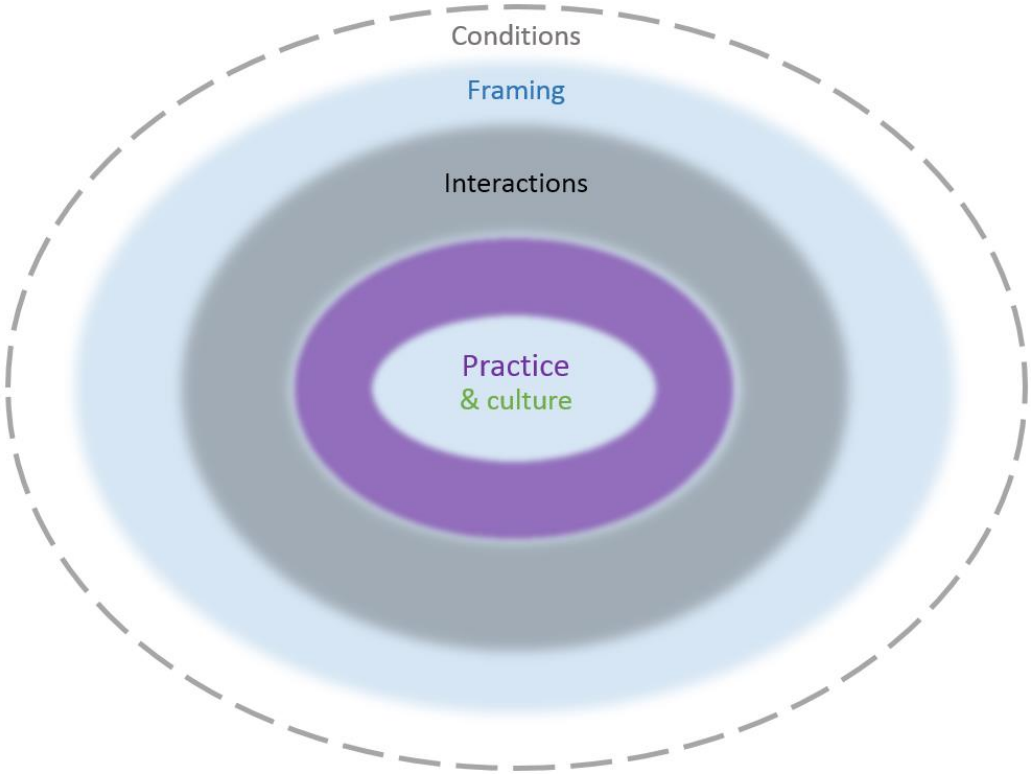


Figure 9.9: Grounded theory for Public Lab as community of DIY practice – situating 'culture and practice' embedded within interactions, framings, and factors enabling/promoting it

The second part of the model, Figure 9.10 portrays the relationship between *culture/practice*, and *values* at its centre. The content of culture is represented as green ovals and *values* are situated as the core of *culture/practice*. The model also portrays the interrelationship between *practice/culture*, *tensions*, and conditions/enablers as they shape each other. These relationships are represented by two-way arrows. The model also portrays that *values held* are the result of interactions, which are sources of tension, but at the same time they function as conditions and/or enablers of engagement.

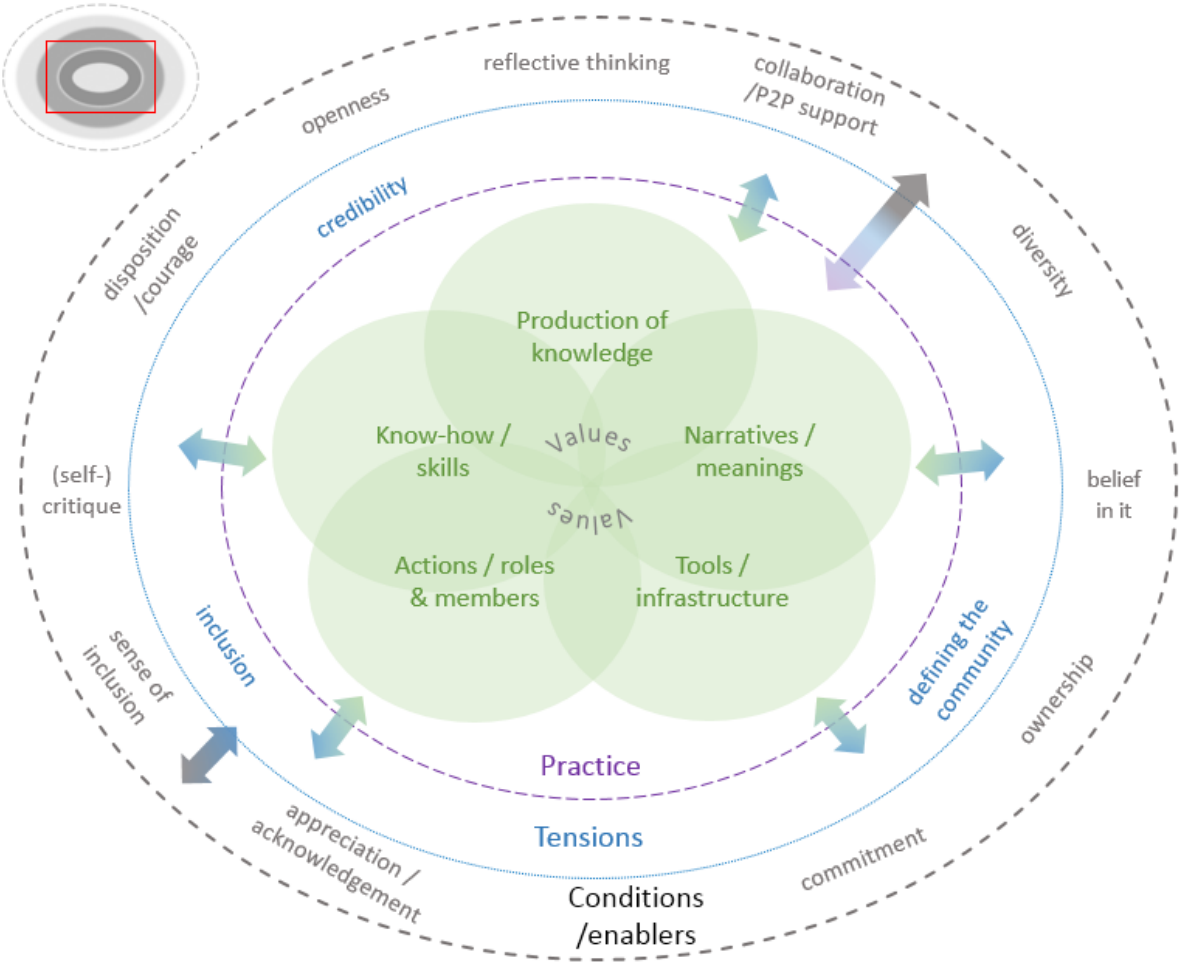


Figure 9.10: Closer look at 'culture and practice' and their relationships to tensions and conditions/enablers

The salient *values held* include *collaborative work*, *being disposed to new ideas*, *openness*, *appreciation*, *solving/ addressing issues*, *sharing*, *access*, *feeling included*, *empowerment*, *diversity*, and *creating opportunities for others*. Based on a community group activity with 21 members who wrote down 10 things that they value most about Public Lab, the salient values are 'community', 'work', 'people', 'collaboration', and 'learning'. These are represented in a wordcloud (Figure 9.11).

Figure 9.11: Word cloud with frequencies for the 'ten things I value about Public Lab' written by 21 community members. Number in parenthesis represents word frequency.

In Figure 9.10 community *culture/practice* is represented by 'actions/roles' (including site-specific engagement, tool-development, outreach, and support on- and offline) and by the members of the community (the people committed to these actions). *Culture/practice* is also represented by 'tools/infrastructure' (hardware, software, platforms, journal, mailing lists, etc.) that are used and developed by the community in various actions/roles. Tools/infrastructure provide support for interactions: idea/knowledge-sharing, ownership over work, learning, identity building, fun and fraternising, etc. Narratives/meanings are also part of *culture/practice* and they represent the various stories and aspects that are appreciated and valued by the members; they provide a basis for defining the community from various perspectives (contributing to tensions). 'Producing knowledge' is also part of *culture/practice* and it is facilitated by interactions through actions, tools, and narratives. It requires learning and, through (self-)critique, it facilitates continuous reflective thinking about purpose and

impact (thus leading to tensions about inclusion, credibility and legitimacy). 'Know-how' is facilitated by openness – infrastructurally and practically through community platforms/media, and ideologically through the environment at gatherings and community ethos. Know-how requires and builds disposition to new ideas and courage to engage in DIY.

9.7 Case conclusion

This case study has provided an understanding of processes and interactions in a community of practice engaged in activities of sociotechnical DIY. It sheds light on how members interact in a grassroots community using and developing DIY tools as well as techniques of DIY enquiry to address social and environmental issues. It also sheds light on how the framing of DIY determines the stance and attitude towards it. I now turn to a review of my initial propositions presented in section 9.1.1 (p.188).

9.7.1 A community of DIY practice: review of propositions on framings, interactions, tools and meanings

The first proposition suggested roles that are internal to the community, where engaged members (doers) mentor newcomers (first-timers), and external roles to which the community respond and in doing so, shape practice. While internal and external roles are discernible in the community, they are better understood as part of a continuum – one that takes shape as members describe their engagement with and contributions to the community. These roles change over time and as members engage with various aspects of the community. For example, a person can consider herself as a mapper in a role supporting others when out flying kites but as an external critic when the topic turns to developing the spectrometer. Being multiple roles is in fact valued by the community as 'welcomed diversity' but not formally acknowledged as an innovation.

I also proposed that there are internal and outward interactions. Internal on- and off-line interactions do provide the rhetoric and shape the ethos that guides the community's actions and tools as suggested. However, interactions also represent the continuous complex

interrelations and negotiations between actions and conditions that give rise to excitement, new ideas and solutions, and tensions. In addition, tensions are only recognisable because there is disposition to new ideas and dedicated spaces to "have hard conversations" [2:61]. Interactions drive practice and vice versa and together they define community culture – influenced, of course, by conditions/enablers. Similarly, outward interactions define and portray culture but are also moulded to target various groups (e.g. emphasis on impact to attract funding).

The third proposition suggested that commitment to open source hardware and software shapes tool making, use, and conception. Linked to the previous, interactions with tools through actions reveals a lot more about how conceptions and commitments shape practice and culture; open source is a value but it is also a culture-building practice, which members negotiate through their relationships with tools and action. These relationships give depth to the community's ethos as members also negotiate their relationship to themselves (their personal interests) and to each other's diverse conceptions about community, culture, and practice.

The fourth proposition suggested that the community's meanings (what it stands for) and its identity is portrayed through its actions and tools. The in-depth analysis of this case study shows that meanings are not only portrayed but are also shaped by framings. As stances, framings provide the lens through which Public Lab is perceived, as seen in 9.5.2. However, meanings can be fragile (especially if not well-defined/anchored); if stakes are high and values are in dispute (Funtowicz & Ravetz, 2003), scrutiny and scepticism of the unknown increases. Reflective thinking enables critique. Critique as scrutiny draws from (clings to) known frames (e.g. canonical science), and when issues are time-sensitive, scrutiny tends to occur only one way (from the canonical perspective); alternative solutions under scrutiny (e.g. grassroots science) are placed in a position unable to scrutinise the scrutiniser. In such cases a dialogue that draws from both perspectives to create new frames is thwarted. However, at the individual and group levels, and through the creation of dedicated spaces (on- and off-line), the opportunity also arises for the scrutinisers to scrutinise themselves. This reveals concerns about issues of exclusion and informs actions towards addressing them.

As frames of reference, conceptions (such as 'science') or values (such as accessibility) guide community reflective thinking (e.g. on how to manage and sustain the community, especially as the organisation grows). Meanings are created as members not only interact with each

other, the tools, and the community environment, but as they make sense of how the different parts (roles, experiences, artefacts, conceptions, etc.) fit together. Meanings are powerful because, through learning and reflection, they become the narratives of 'who we are' and 'who we want to be': they provide purpose. This process in turn shifts and refocuses frames of references that shape and guide the journey to new goals and new stories. Communities of practice have the collective capacity to re-draw and anchor frames that not only withstand institutional scrutiny but that can firmly invite it to dialogue on firm and (new) equal ground. Together, these insights shed light on the intricacies of DIY enquiry as it unfolds in a community of practice – though their action, culture, meanings, and interactions with others, artefacts, and production of knowledge.

We now turn to the second case study (Chapter 10, case background and Chapter 11, case analysis) moving from 'researcher as participant' to 'researcher as facilitator' in the study of engagement in DIY enquiry through playshops. Chapter 11 presents a theoretical model that explains the interplay between workshop environment, personal sphere, social context, and conditions for engagement in the playshops, with a focus on the consequences of engagement and what interactions within mediate and are mediated by.

10. Public engagement in DIY enquiry through playshops: Case study background

We now move from 'participant observation' in a community of DIY practice to public engagement in DIY enquiry through playshops as a case demonstrating the initial stages of engagement in DIY at the individual level. It also reveals insights into the consequences of and barriers to engagement as well as the conditions for engagement in DIY and ways to overcome these barriers. In the first part of this chapter I describe the history, design, and implementation of the playshops. The second part presents the methodological strategy for this case: contributions to theory, rationale, design frame, and sources of evidence.

10.1 Background

The playshops series used in this case study were developed and continue to be imparted through the London-based group Citizens without Borders (CwB). Founded in 2011, the purpose of the group is to create spaces to explore our environment and build our capabilities to do so – practically and experientially. This is done through activities that fuse arts, sciences, and everyday life (Regalado, 2015b).

While there are many spaces where people can engage in hands-on learning and problem solving activities such as FabLabs, hackspaces, and makerspaces, these spaces are often defined by strong cultures, identities, and manifestos (such as the 'maker ethos') that can be in themselves barriers to entry for people who know nothing or very little about DIY. The general CwB approach aims to address some of these barriers. To address them, they first need to be understood and the playshops provided an opportunity to study this. CwB also provides several avenues for engagement in various topics and using different media/formats: guided tours, film nights, debates, etc.

Through CwB I have designed various playshop series including *Exploring borders through art* (using artistic expression as a medium to explore our conceptions of the world), *Explorer of the world* (EoW – building on the previous, using DIY tools and techniques to explore 'how we explore' the world around us), and *For the love of mess* (using lessons learnt from the

previous playshop series to overcome 'fear of erring' and using mistake-making as a medium to experiment with unexpected outcomes). Playshops in general aimed at delivering activities that stimulate the imagination, wonderment, exploration, and experimentation in a playful and inviting manner (hence the name 'playshops'). This case study focused mainly on EoW playshops.

In this case study I performed as a researcher, a facilitator, and a participant observer. My role as a facilitator enabled me to fully engage in the playshop activities being investigated in a fundamentally new way, drawing on methods from Participatory Action Research (PAR), Ethnography, Critical theory, Education, and the Hacker/Maker movements.

10.2 The Explorer of the World playshop series: design and implementation

The participatory approach in the playshops is based on PAR methods and the DIY/Hacker ethos. The PAR practice-based method promotes empowerment through participatory enquiry grounded in participants' needs. The essence of DIY and the Hacker ethos is one of self: self-reliance, self-learning, self-drive, and being self-directed (Emerson, 1841; Wehr, 2012). When applied to workshop design, the DIY approach means people have full ownership over their learning process as they explore and figure things out in their own way. Thus, my role as facilitator was to provide guidance and support in a self-led process of hands-on learning aimed at capacity building. In the next section I describe this facilitation role as well as the planning, contents and materials, how the playshops unfold and the engagement in them.

10.2.1 Playshop planning

The metaphorical 'canvas' of the playshops was predefined by the purpose of CwB and goal of the playshop. The content, or what would metaphorically fill the canvas, kept in line with PAR and DIY principles of self-directed learning and capacity building: based on attendees' interests, needs and ideas. These pointed the direction of the exploration and the facilitator provided guidance at every step of the workshops. Thus, the methodology for the EoW

playshops was adaptive and the goals for each playshop were achieved in unique and distinct ways reflecting the character, state of mind, and interactions of the researchers/players. This openness and flexibility meant that each workshop and individual activity was as unique as the participants involved.

10.2.2 Playshop facilitation

There was a distinction made between *training* and *supporting* and between *participant* and *enquirer/explorer/first-timer*: the participant becomes an enquirer/explorer/first-timer as they are taken through a process of (self-)enquiry to discover for themselves how they would pursue their own exploration. The aim was to create an environment conducive to ownership over knowledge and understanding: thinking of *experiments* rather than *mistakes*, peers learning from each other, multiple media and resources available, several iterations, time dedicated to reflective discussion, and playfulness. As PAR practitioner Rahman (2008) explains: "those who are taught, rather than stimulated to search for themselves would, in turn, be prone to 'teaching' others in their charge rather than stimulate self-enquiry in others" (p.52).

10.2.3 Playshop performance and delivery

The EoW playshops were delivered in a series of five bi-monthly two hour playshops. Each playshop built on the learning, experiences, and materials from the previous playshop. From past experience I hypothesised that this continuity would provide the opportunity for attendees to build relations, experience and knowledge (about their engagement with themselves and others). I also expected that this accumulation of experience and knowledge would create environments that were welcoming to newcomers as peers shared these with new peers. The planning and delivery of the playshops' content was also guided by the questions, qualms, and interests of the attendees (which I noted down after each playshop). The latter added to the depth of understanding of engagement in DIY enquiry, barriers and opportunities to entry, and strategies to overcome or use these. The playshops were conducted both indoors and outdoors and scheduled to be as inclusive as possible during weekday evenings (after working hours) and on weekends. The final playshop in the series aimed at bringing together all the experiences, reflections, and learning from previous playshops by giving them material representation as artwork.

10.2.4 Playshop contents and materials

The content of the workshops, and the EoW playshops in particular, was inspired and aided by several approaches including Keri Smith's (2011) book 'How to be an explorer of the world'. This book merges the methods of scientific enquiry and ethnography. Other influences have been Gertz and Justo's (2012) 'Environmental monitoring with Arduino' and Tom Igoe's (2011) 'Making things talk: Using sensors, networks, and Arduino to see, hear, and feel your world'.

The main criteria for the contents of the playshops were that first, activities or the experiences involved had relevance or a link to their everyday lives; second, that it promoted interactions with peers, artefacts, and the environment; and third, that it promoted self-directed exploration. Materials used included mixed media (from action-cams to repurposed electronic equipment and scavenged finds) and used experiential approaches ranging from observation and rapid-prototyping to improvisation theatre for self-directed learning. In all playshops attendees were encouraged to keep a personal *explorer's journal* (Figure 10.1). Some of their notes and sketches were then shared in blog posts written by the playshop attendees themselves (Figure 10.2).

10.2.5 Playshop series structure

The EoW playshops had three iterations (Table 10.1). The first EoW playshop in 2013 was inspired by a workshop given by Tom Igoe at the Citizen Science Summit in 2012 and it also built on the experience accumulated from running the first iteration of *Exploring borders through art* (EBtA) playshops. The new format of EoW for the second iteration was discussed and drafted informally with people who participated in the EBtA playshops. The new format separated the playshop content into its constituting elements: introduction, learning to explore, putting exploration to use, and wrap-up. Each element became a playshop to delve deeper into each step. This new EoW format was delivered soon after the second iteration of EBtA. While the EBtA playshops facilitated self-enquiry and self-expression with art as a medium, the EoW playshops focused on external enquiry using our senses and DIY tools.

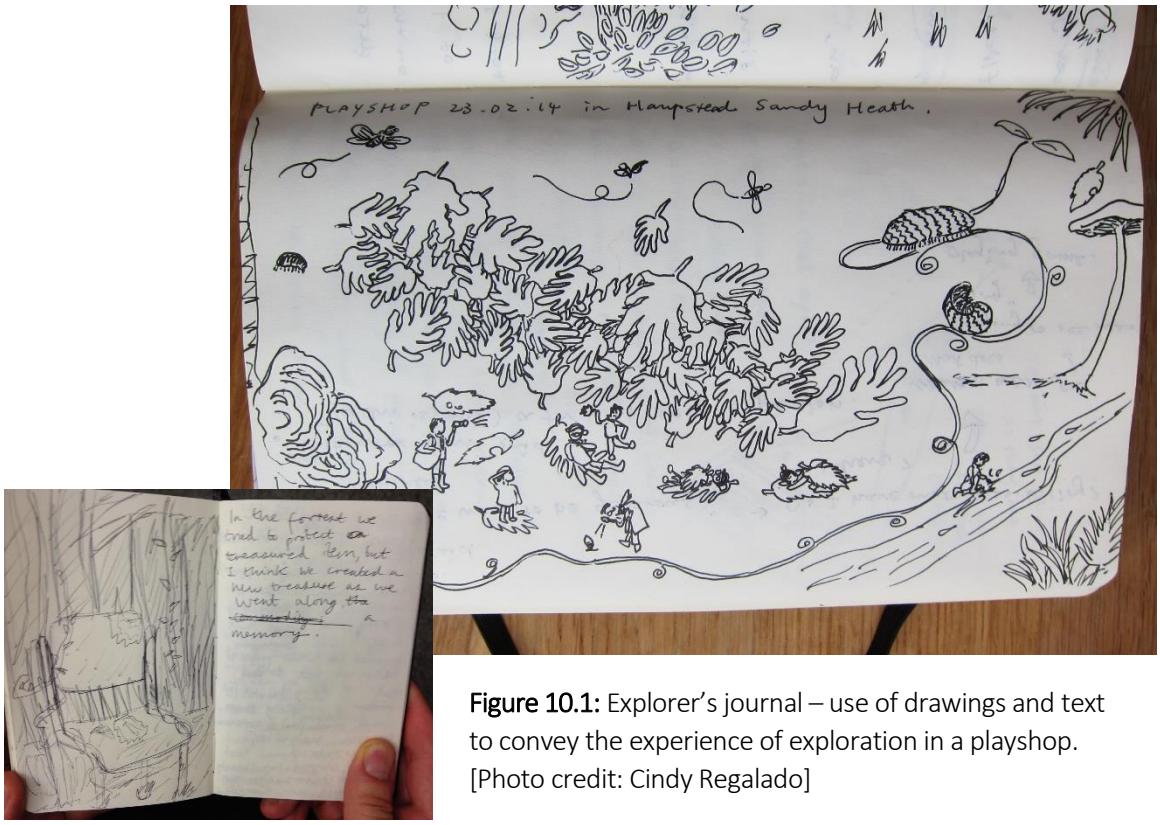
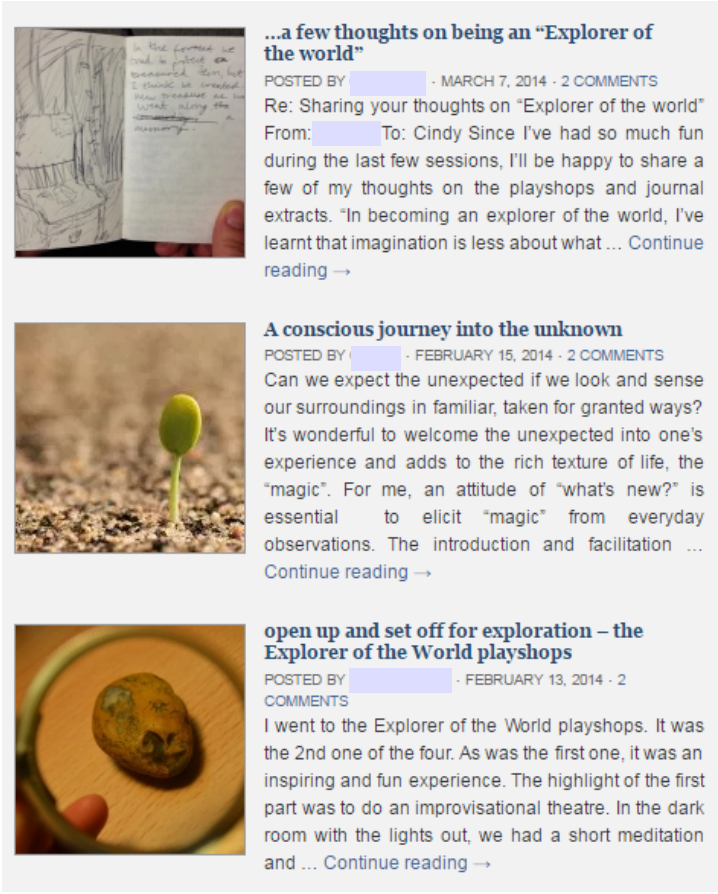


Figure 10.1: Explorer's journal – use of drawings and text to convey the experience of exploration in a playshop. [Photo credit: Cindy Regalado]



...a few thoughts on being an "Explorer of the world"

POSTED BY [redacted] · MARCH 7, 2014 · 2 COMMENTS

Re: Sharing your thoughts on "Explorer of the world" From: [redacted] To: Cindy Since I've had so much fun during the last few sessions, I'll be happy to share a few of my thoughts on the playshops and journal extracts. "In becoming an explorer of the world, I've learnt that imagination is less about what ... Continue reading →

A conscious journey into the unknown

POSTED BY [redacted] · FEBRUARY 15, 2014 · 2 COMMENTS

Can we expect the unexpected if we look and sense our surroundings in familiar, taken for granted ways? It's wonderful to welcome the unexpected into one's experience and adds to the rich texture of life, the "magic". For me, an attitude of "what's new?" is essential to elicit "magic" from everyday observations. The introduction and facilitation ... Continue reading →

open up and set off for exploration – the Explorer of the World playshops

POSTED BY [redacted] · FEBRUARY 13, 2014 · 2 COMMENTS

I went to the Explorer of the World playshops. It was the 2nd one of the four. As was the first one, it was an inspiring and fun experience. The highlight of the first part was to do an improvisational theatre. In the dark room with the lights out, we had a short meditation and ... Continue reading →

Figure 10.2: Blog posts written by attendees to Explorer of the world playshops.

Table 10.1: Explorer of the world playshop list

Playshop	Description	Date	Iteration
The explorer's makeshop 'Exploratorium': let's make stuff!	Introduction to DIY electronics	Mar 2013	1st
Exploring borders through Art (EBtA) playshop series			
Explorer of the world: 1st playshop - We are all explorers!	Exploring ourselves and tools for exploration	Jan 2014	2nd
Explorer of the world: 2nd playshop - Observe, contemplate, wonder	Exploring methods: observation, induction, and deduction	Feb 2014	
Explorer of the world 3rd playshop: Explorer's day out! (+ picnic)	Exploring outdoors and 'classification' methods	Feb 2014	
Explorer of the World 4th playshop: Bringing it all together!	Giving material representation to experience of exploration	Mar 2014	
Explorer of the World 5th playshop: Explorer's day hacking	Enquiry of technology and artistic representation of hacking experience	Mar 2014	
Exploring borders through Art (EBtA) playshops series			
For the love of mess playshop series			
Explorer of the world: 1st playshop - We are all explorers!	same as original	April 2015	3rd
Explorer of the world: 2nd playshop - Observe, contemplate, wonder	"	May 2015	
Explorer of the world: 2nd playshop - Observe, contemplate, wonder	"	May 2015	
Explorer of the world 3rd playshop: Explorer's day out! (+ picnic)	"	May 2015	
Explorer of the World 4th playshop: Bringing it all together!	"	June 2015	

After the 4th playshop in the second iteration of EoW, participants who had taken part in EBtA playshops prompted the incorporation of artistic elements from EBtA into EoW. The result was *Explorer of the World 5th playshop: Explorer's day hacking*, which combined elements of enquiry and wonderment with artistic expression focusing on technology. It is important to note the intertwining between the EBtA and EoW playshops; several of the attendees felt little or no need to differentiate between them, as one of them stated:

> So actually even though we think of them as two different series, I actually think having done the first Explorer – Exploring borders through art series did help a great deal to get even more of the series on Explorer of the world, so maybe we should think of them as one series [3:124].

10.2.6 Playshop engagement

As mentioned earlier, the playshops were scheduled and promoted through the meetup.com platform, where CwB has a 'meetup' group. People are not actively recruited to CwB nor the playshops. Rather, they are self-selecting to the meetup group and we promote engagement in playshops at other CwB more passive events such as film nights. At these events we invite people to explore, hands- on, the topics that are discussed. On the platform, the event descriptions outlined what would be learnt during the playshop and what participants should bring with them, if anything (e.g. materials for repurposing). The platform enabled attendees to share their thoughts after the event. Online surveys after the activities were rarely filled out; people seemed to prefer leaving comments on the event webpage to share their insights and reflections with others after the fact. The playshops were also promoted at other CwB events such as film nights.

10.3 Methodological strategy: DIY enquiry through playshops

Contribution to research: Insights from this case contributed mostly to the development of the bottom right quadrant in the theoretical framework (Figure 5.1, p.107): issues of (self-)trust in knowledge production and engagement with DIY tools. The activities in the playshops represent the discourses and actions undertaken by the participants, as individuals and groups, with regards to engagement in DIY enquiry. Discussions about DIY during the playshops varied greatly, ranging from conversations about what DIY is and what it means to engage in it, to discussions about DIY methodologies and conversations about what is possible through these DIY practices. In some cases, as a facilitator, I prompted these discussions, and in others, they arose as part of engaging in the activities. The most predominant theme evident through initial data analysis (first and second iteration) was that 'courage' is the most important 'tool' for engaging in DIY because it provides a foundation for initially trying out the activities and to then continue engagement in them. Further and deeper data analysis revealed more nuanced processes of engagement in DIY enquiry

(especially the initial steps) to understand the barriers and opportunities to entry into it, and the strategies that can be sued to overcome or take advantage of these.

Selection rationale: This case study was selected because the perspective of a workshop setting is especially suited to understanding the initial stages of engagement in DIY enquiry as people are first introduced to it through hands-on experiential learning over a period of time. This also facilitated the study of the barriers and opportunities of engagement in DIY, learning directly from participants during the time allocated for reflection in the playshops and at the end of the playshop series but also during the interviews.

Design frame: This case study is local as the unit of analysis is the workshops. In addition, I have gained personal knowledge of the group through my engagement in the workshops and the community's additional activities beyond the workshops. It is a key case because a workshop setting provides key insights into the processes of engagement in DIY enquiry at the individual and group levels. It is also a crucial case in that strategies for overcoming barriers to engagement are identified and designed by the participants and the facilitator throughout the playshop series. As with the other cases, the purpose of the case is instrumental in that it contributes insights at the personal and group levels that complement the perspectives of the other cases (at the organisational and contextualised community levels) in the understanding of the broader picture of DIY enquiry. It is also an exploratory case in the heuristic sense because through experimentation and allocated reflection these workshops explored the little understood processes of engagement in DIY enquiry. Specifically it guided the research in identifying the themes and categories of DIY enquiry (initial stages of engagement, barriers, opportunities, etc.) and determining ways of studying and conceptualising these, to then propose explanatory relationships. As with the previous main case, all empirical data collected was used in the theory-building approach of Grounded Theory. This case is also part of multiple parallel case studies with elements of research interest nested across cases. The design frame is illustrated in Figure 10.3.

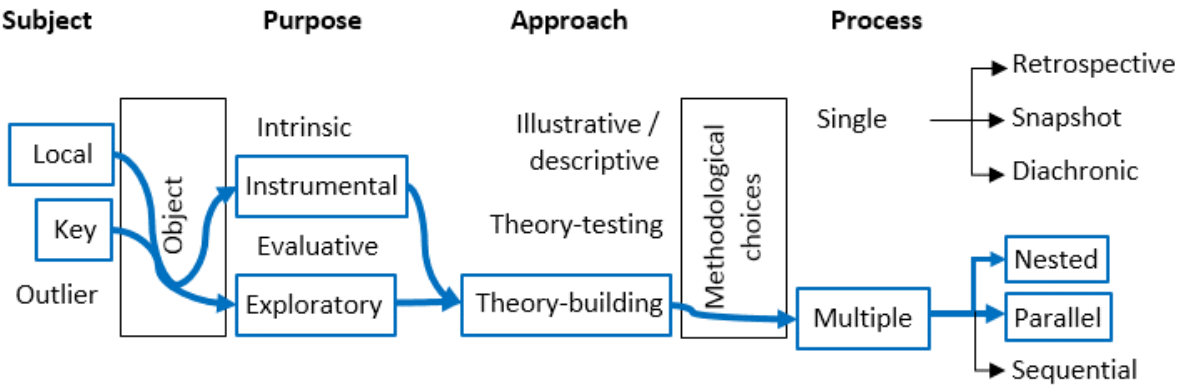


Figure 10.3. Research design for public engagement in DIY enquiry through playshops case study.

Sources of evidence: The data used in this case comprises mainly of interviews, blog posts written by workshops participants, and field notes gathered since 2012. These are listed in Table 10.2.

Table 10.2: Sources of evidence for public engagement workshops case study

Data type	Description	Year
Audio recording	• Conversation about mission and vision of engagement activities growing a community	2011
Blog posts	• 14 blog posts by participants in workshops – reflections on process, their participation, experiences & personal journey in DIY	2013-15
Audio recordings / interviews	• 4 group discussions – reflection time at end of workshop activities to share insights, experiences, challenges, future changes to workshop design • 6 in-depth interviews with workshop participants about their experience in the workshops (*interview guide based on theoretical concepts and framework*)	2014-15
Videos	• Materials produced at Explorer of the World playshops	2014
Field notes	• Observation notes and reflections on workshop design, public engagement – challenges/opportunities, DIY tools used/developed	2012-15

With this background on the study of engagement in DIY enquiry through playshops, we move to the case study analysis, which offers a Grounded Theory explaining the phenomena in DIY enquiry through playshops.

11. Public engagement in DIY enquiry through playshops: Case study analysis

11.1 Comparative process and research dimensions

To set the scene for the analysis, I start with a preliminary conceptual model, initial guiding concepts that support it, and initial propositions about engagement in DIY enquiry, and the process of theoretical sampling that follows from deeper analysis. The second section of the chapter presents the results from theoretical sampling. The third section focuses on the theoretical integration model and presents the Grounded Theory for DIY enquiry through playshops. I end with a discussion comparing the preliminary conceptual model (hypothesis) and the Grounded Theory for this case study.

11.1.1 Initial guiding concepts and preliminary conceptual model

I developed initial guiding concepts based on my initial experiences from the pilot cases (see section 7.2, p.145), initial iteration of EoW playshops (see Table 10.1, p.230), and experiences in the other playshops and workshops. Further informal discussions with playshop attendees and participants at the Citizen Science Summit led me to develop a conceptual model for engagement in DIY activities.

These initial concepts directed the research questions towards citizen-led initiatives in public engagement in science and technology. Alongside an initial literature review, the preliminary *open coding* of interviews and participant observations led to *generative questions* about the roles of the institution, technologies, the setting, and other conditions hindering, maintaining, or promoting public engagement. It also led me to ask how people begin engagement in DIY. Through iterations of the playshops preliminary answers to these questions began to emerge. These in turn provided a starting point for deeper analysis and the theoretical sampling.

Figure 11.1 illustrates the preliminary conceptual model for engagement in DIY and initial guiding concepts. Initial analysis of workshops and playshops revealed three main concepts and assumptions about engagement, trust, and community.

Engagement emerged as a main theme and focused on questioning the role of facilitators of engagement. It originally focused on engagement *facilitated* by the institution, in this case my association to UCL (as opposed to self-initiated DIY activities). This pointed out the need to critically examine the conditions of facilitation and the role of the facilitators in 'engagement'. Further review of the literature on public engagement revealed that, with the exception of Action Research, facilitation and conditions of facilitation are not a central theme and in fact, are mostly taken for granted.

Trust focused on participants' experience of DIY and assumptions about capacity building. The initial analysis revealed that *courage* (portrayed as 'trust' in Figure 11.1) was the most important 'tool for engagement' developed through the activities in the workshops. As one participant commented after an event at the MCC:

> To be honest, I do not really need these [kite-mapping] skills. I have no need for this in my life right now. But what I do know right now is that if I ever needed to do anything like this, I know I can – and that, that is more valuable than anything.

Community focused on communities of practice, how practice is performed and how communities form around practice.

These insights set the foundations for initial propositions (hypotheses) and model on engagement in DIY. The first proposition was that in these instances of facilitated 'doing-it-yourself' engagement there was evidence of self-driven capacity building and that it was '*gaining*' this '*courage*' or *(self-)trust*[23] that enabled people to continue their engagement – in the same or other activities related to DIY. In the literature, this was in line with conceptions of 'self-reliance', 'self-learning', 'taking initiative' and 'ownership' (e.g. Ashcroft and Foreman-Peck (1994, in McMahon, 1999); Douglas', 2016; Baljko & Hamidi, 2014; Fischer, 2011. Initial observations seemed to suggest that the environment or setting of *engagement* contributed to- but was also created by participant's trust.

[23] This represents a link to the theoretical framework to be explored in Chapter 14.

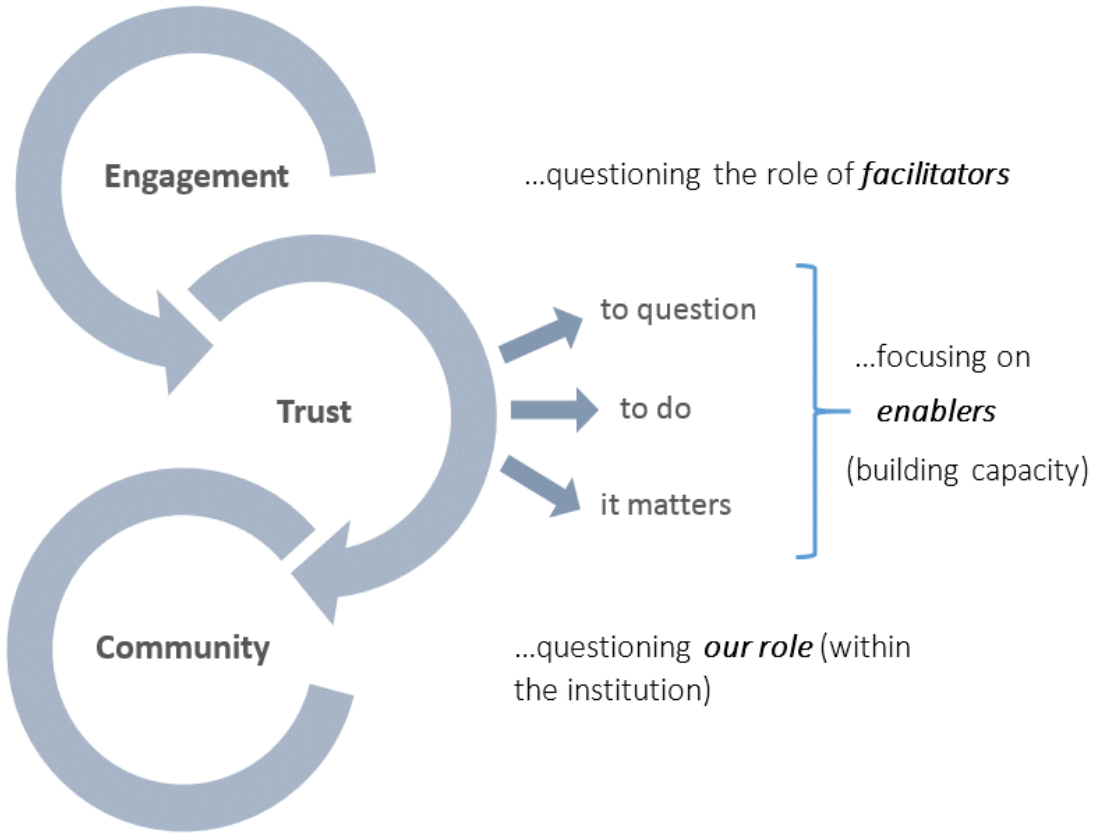


Figure 11.1: Preliminary model and initial concepts of engagement in DIY enquiry through playshops

Thus, my second proposition was that while an environment of DIY practice can be facilitated (e.g. by mentors), it is DIYers who are in fact enablers of their own capacity building. Specifically, initial observations from the playshops and workshops led to three key insights:

- People build trust in their ability *to question* the world around them (the system, authorities, their judgement) through engagement;
- people begin trusting and believing in their abilities *to do*, i.e. a belief in that they *can* take initiative and *can* develop capacities to build/use tools, methods, and critical thinking; and
- people begin believing that what they do actually *matters* i.e. that it is important; they trust that the fruits of their efforts will actually materialise into something tangible.

This provisional proposition is illustrated in Figure 11.1 as *enablers*.

My third proposition was that engagement in DIY activities such as Touch|Play|Learn prompted the participants to engage with tools and techniques of science (e.g. data gathering tools and methods – aerial mapping, observation, data logging, etc.) in their own way. Through this they also developed skills to reflect on and question the impacts of their engagement. That is, I hypothesised that *engagement* occurred in a way that encouraged participants to discover for themselves how they could pursue their own investigative explorations. In developing the playshop methodologies, I designed an approach in which DIY practices were grounded in the interests of the participants (surveyed between playshops in group and individual discussions) and in this way it was assumed that the activities could be made more relevant to their lives.

The third element of the model represents my fourth proposition: *communities* of practice develop as people who acquire skills pass them on to others – peer to peer. The model assumes that building communities of practice requires questioning the role of the institution: if people are to take initiative in DIY enquiry and research, what role should the institution play? This further led to questioning the role of the facilitator (operating from within the institution). It also led to noting the tensions between different participatory approaches to engagement in the literature as well as the conditions needed for those approaches. The literature on AR (e.g. Kemmis, 2008) for example, argues for providing opportunities to learn about and engage with people's existing abilities, passions, and knowledges, while others note that currently there are limited political and institutional interests and organisational infrastructure to support/include them (Rydin, 2007).

This provisional explanatory model informed and was informed by the playshops. As iterations of the playshops continued, practical challenges emerged in the methodology of the playshops themselves. For example, balancing between being open to the direction of the group or individuals while resisting the temptation of imposing a particular learning outcome (countering the purpose of DIY), and thereby losing focus of the experience and coming to no learning or reflection at all – as noted by Jacobson and Ruddy (2004). However, what is apparent in the initial analysis and literature review is that this balance was also mediated by interplay between micro- and macro-factors contributing to engagement. Hence, my fifth and final proposition was that both individual and institutional levels play a role in creating conditions for engagement. The three elements of the provisional model

emphasise these two levels: peers and facilitator on the one hand and the institution on the other.

As part of the comparative process (and in seeking to confirm or disprove provisional concepts and propositions) I gathered feedback from reflective discussions with peers and other scholars at conferences related to public engagement, citizen science, education, and critical-making. It became apparent that there were many assumptions in this provisional model and that further generative questioning was needed to understand the practice of DIY enquiry. This generative questioning led to revision of the salient dimensions of these themes and further subdimensionalising.

11.1.2 Dimensions and subdimensions

Table 11.1 lists some of the salient categories and subthemes generated during open coding of this case study. A complete list of the 60 codes identified for this case study can be found in Appendix C.1.

While *engagement* emerged from observation/practice as a main analysis category, its subdimensions are mainly guided by the Grounded Theory coding paradigm and concepts in the literature. *Defining process* is a salient and completely emergent theme entirely grounded on the data. The subdimensions of the categories *Response* and *Sharing* emerge from generative questioning of the subdimensions of *Engagement*. For example, what does this 'condition for engagement entail', 'why is this a barrier', and 'how is this consequence manifested'? Generative questioning and directed enquiry led to theoretical sampling to then integrate theory (section 11.6, p.263).

Table 11.1: DIY enquiry through playshops - categories and their subdimensions (or subthemes) – generated during open coding

Category	Subdimension	Grounded	Density	Description	Source
Engagement	Consequence of engagement	77	16	Describing what happens as consequence of engaging	Coding paradigm
	Condition for engagement	57	14	Things that need to be or are in place for engagement to occur or continue	Coding paradigm
	Barriers to engagement	52	9	Blocks engagement in an activity or performing a task	Literature
	Defining process of engagement	43	16	Mentions/instances of engagement process being defined/described by participant	Data
	Different ways of seeing/doing	42	12	Different ways of seeing or doing things: enabled or achieved	Data / Literature
	Reason for	26	9	Why people engage (personally or for others)	Data / Literature
	Initial steps in	22	11	Initial experiences of engagement in DIY	Data / Literature
Interactions	Interactions with others	55	16	Interactions between people	Coding paradigm / Literature
	Interactions with artefacts	43	16	Interaction with material or symbolic objects	
Comfort zone	Comfort zone extended	38	10	Coming out of or disrupting personal comfort zone	Data
	Staying within comfort zone	27	4	Wishing to, wanting to, or unable to extend comfort zone	Data
Knowledge	Reflective thinking	46	11	Instances when interviewee wonders about something or questions something they say	Data
	Enquiring	31	14	Actively questioning, wondering, asking, trying to understand reasons or relations between things	Data / Literature
	Personal meaning-making	30	3	Creating personal meaning	Data
Activity	Making	31	4	Process of making – an artefact (symbolic or material)	Data / Literature
	Exploration as activity	26	1	Engagement in exploration as activity	Data
Response	Appreciation	36	8	Expressing appreciation, excitement, or being pleased	Data
	Sense / issue of connection*	36	9	Perceived (or lack of) connection to self, others, objects,	Data / Literature

				circumstances, past, present, future	
	Response: joy	22	2	Expressed joy or enjoyment	Data
	Courage / self-trust	21	7	Self-trust or courage (personal or expressed about others)	Data
Science	Conceptions of science	16	2	'Science' as a topic	Data
	Science activities	12	2	'Science' as activity e.g. observation, collecting information or specimens, experimenting, measuring, testing, etc.	Data / Literature
Sharing	Experience(s)	32	3	Marks description of people engaging in sharing an experience (as perceived by coder or as described by interviewee) ≠ sharing knowledge	Data
	Meaning	16	1	Marks instances of people described as sharing meaning (as perceived by coder or described by interviewee) DIFF. FROM instances of sharing knowledge	Data
Context	Workshop environment	92	19	Workshop environment/setting (inter-actions, engagement in activities, etc.)	Data
	Personal sphere	58	18	Personal environment or mental/ mental inner world (thoughts, reflections, etc.); of personal relevance	Data / Literature
	Social sphere	16	2	In relation to society, about or towards society	Data
Medium	Artistic expression	52	9	Artistic expression during workshops – discursive & non-discursive	Data
	Artefacts	23	6	Artefacts mentioned - material or symbolic	Data / Literature
	Senses	21	1	Use or recalling of senses	Data
Frame	Judgement	35	8	Forming opinion in terms of wright and wrong	Data
	Expectation	28	2	Looking forward to or anticipating something w/reason or justification (in relation to something)	Data / Literature

* The two themes on 'connection' were conflated as it was noted that interviewees talked about them together.

11.1.3 Theoretical sampling

Sections 11.2 to 11.5 provide evidence for the relationships between the most grounded and dense subthemes in Table 11.1. The selected themes of public engagement in DIY enquiry through playshops are:

- *Consequence of engagement* and its relation to 'workshop environment', 'reflective thinking' and 'enquiry', 'different ways', and 'comfort zone extended';
- *Barriers to engagement* and its relation to 'staying within comfort zone' and 'conditions for engagement'; and
- *Initial steps in engagement* in relation to 'making', 'artistic expression' and 'reasons for engagement'.

I present the analysis of each of these next.

11.2 Theoretical sampling: consequences of engagement

With 77 occurrences in the data (Table 11.2) *consequence for engagement* emerges as a salient theme linked to most code categories. Table 11.2 shows that *consequence of engagement* is associated with the 'contexts' *workshop environment* and *personal sphere* (two additional salient themes). The main *consequences of engagement* are in the category of 'knowledge' – *reflective thinking* and *enquiry*; 'response' – as sense of *appreciation*; 'engagement' – *defining process* and *different ways of seeing/doing*; 'interaction' – *interacting with others*; and 'comfort zone' – *extension of comfort zone*. The most salient 'frame' of reference linked to *consequence of engagement* is *judgement* (forming opinion in terms of wright and wrong, as described in Table 11.1). Additional themes associated with *consequences of engagement* include *connection* and *exploration*.

Table 11.2: Categories and their subdimensions (or subthemes) linked to the salient theme *consequence of engagement*.

Salient theme (groundedness)	Category	Subdimension	Co-occurrence	Co-occurrence frequency
Consequence of engagement (77)	Context	Workshop environment	64	0.35
		Personal sphere	46	0.30
	Knowledge	Reflective thinking	43	0.34
		Inquiring	28	0.21
	Response	Appreciation	37	0.26
		Issues/sense of connection	23	0.15
	Engagement	Defining process	34	0.25
		Different ways of seeing/doing	35	0.23
		Condition for engagement	30	0.18
		Reason for engagement	19	0.14
		Barrier to engagement	19	0.09
	Interaction	Interaction with others	42	0.22
	Comfort zone	Comfort zone extended	29	0.22
	Frame	Frame of reference – judgement	36	0.21
	Activity	Exploration as activity	22	0.15

Figure 11.2 shows the theme map for *consequence of engagement*. Again, the main subthemes discussed in this section appear in the blue boxes, including an interesting insight into the interplay between *consequences of-* and *conditions for engagement* that emerged in the analysis. The main insights from these subthemes are summarised in the white boxes.

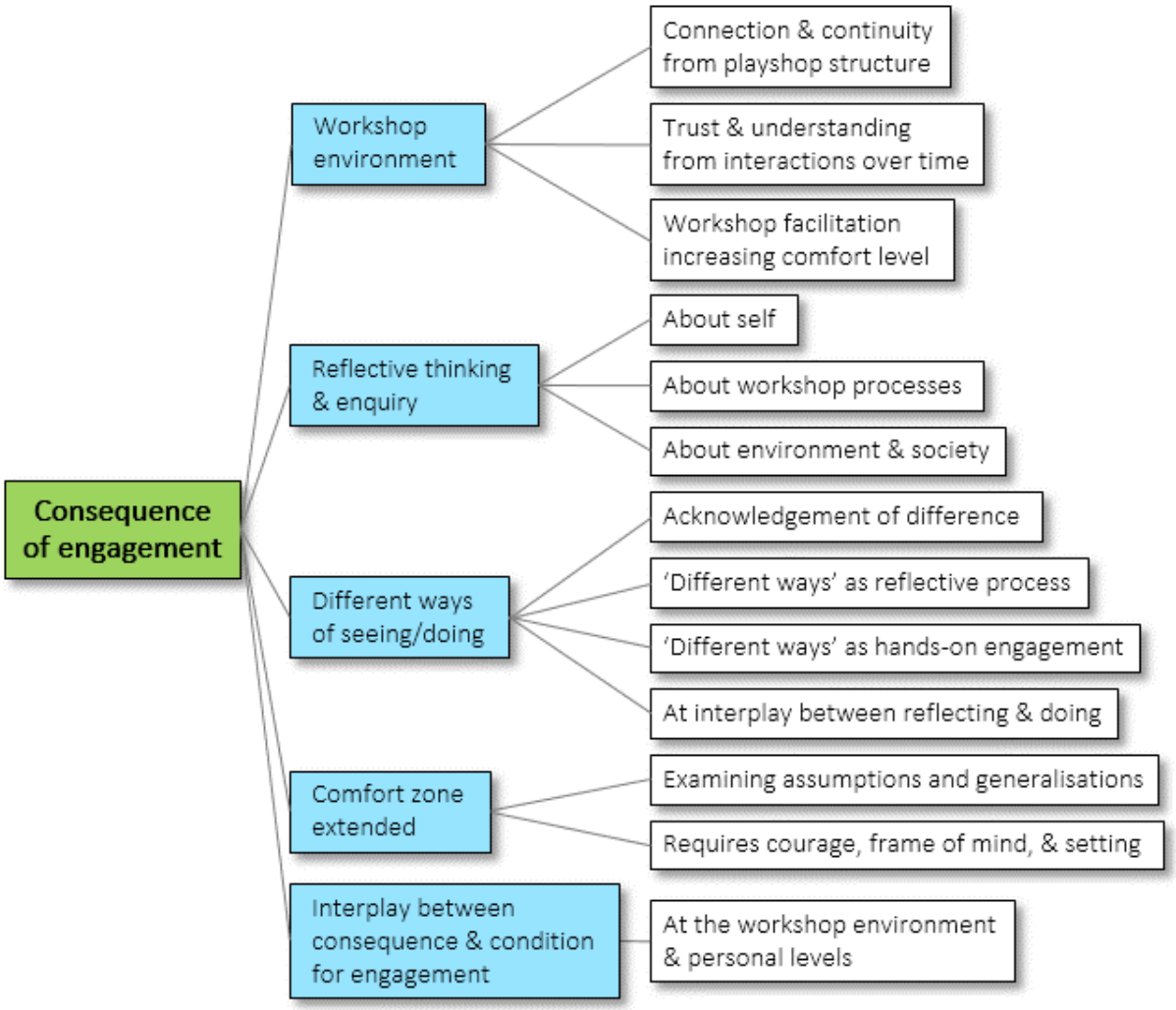


Figure 11.2 Theme map for 'consequence of engagement'.

11.2.1 Workshop environment

One of the main features of the *workshop environment* is the connection and continuity arising from playshops occurring in sequence as a series; analysis revealed that through continued engagement participants built connection with each other, the playshop method (including use of various media), but above all, with themselves. Within the *personal sphere* this went hand in hand with ownership / acknowledgment of their ability to explore and engage in enquiry.

The main premise is that as people interact over time in the playshop environment, they develop further understanding and trust, which in turn helps to lower *barriers to engagement*. A playshop participant explains:

> I think because the settings was done so well, it really helped overcome the inhibitions I had about self-expression. And to have such enthusiastic fellow playmates going, really going for it; that helps a great deal, so yes, I had the barriers of "Oh, I'm going to look a bit foolish here", and not knowing how it's going to be responded to what I do. And initially you think "what's going to come of this, is this going to be a bit sceptical" but for me, that was all removed after the first, after the first – well, after I created my first artwork I knew that… and in that type of expression, my barriers had been fairly easily overcome. [2:74]

The quote illustrates the *process of engagement* within the playshop setting: the inhibitions that were initially in place (i.e. judgement from interaction with others) and the conditions for overcoming these barriers to engagement (i.e. enthusiastic environment and finding a medium for self-expression).

Another consequence of engagement is that *interactions with others* as well as the use of *artefacts* facilitates different ways of seeing and experimenting (as I explain in section 11.2.3, p.246). However, the realisation/awareness of this consequence is facilitated by a workshop environment in which there is prioritised time for feedback (*interactions* become *condition for engagement*) as seen in the quote below. Therefore, the main condition for engagement in the workshop environment is reaching a high comfort level (trust in themselves and between participants):

> [I]f I think about everything that we went through in the playshop we became – we did learn to embrace vulnerability. […] So one thing that stood out about the celebratory workshop was that we all stayed behind afterwards because we all liked the depth of discussion that we have gotten to, and we just wanted to continue. I mean the security guard came to kick us out of the room, so we went back to the other lab, and we sat down on the couches there and kept discussing. And I felt very comfortable telling all the details of why I had made what I had made. [3:60]

11.2.2 Reflective thinking & enquiry

Enquiry and reflective thinking are predominantly linked to and mediated by the *personal sphere* and *workshop environment* contexts and are about the self, the workshop process, the natural environment, and society.

The analysis revealed that participants explored the self through playshops: "I think it is about self-expression and to some extent self-analysis through others" [3:143] and it is done "through different times and from different angles" [4:76]. Playshops enabled an exploration

of 'the extent' of personal *comfort zones*, 'social inhibitions' as well as reflection on the process of engagement and their personal 'transformation' as consequence of engagement (detailed in 11.5). Reflective thinking also focused on exploring personal interest further, gaining appreciation of the connections revealed through engagement, and the process of reflective *sharing* as a group.

> I think almost all enquiry is either started by curiosity or it is started by some sort of necessity in determining the cause of something […] But true novel enquiry usually starts with curiosity and, yes, I think all of that really – especially finding the things outdoors and showing them to each other because we had found different things that – another one of us might have overlooked but they were pointed out by someone else, and "Look", "Okay… okay!" I remember a lot of people saying, "Oh wow! Yes, oh where did you find that? And oh that's really cool. Can I have a look?" And it was quite playful. And because of the tools available, the magnifying glass and the water, I remember people saying, "Oh it looks very different through water than it does just dry." So, yes, it was – it also stimulated people trying to see things through different media. [3:8]

Reflection is also linked to enquiry and expectation about future engagement "how I am going to react the next time" [1:113], and wondering about other participants' assumptions and motivations for engagement.

Enquiry and reflective thinking surrounding workshop environment and process ranged from how "different backgrounds" [4:58] come together, the use of various media providing *different ways of seeing/doing*, and how to further their or the group's enquiry and reflection, to the 'scalability' and reproducibility of methods, and prospects for the group's future.

Enquiry and reflective thinking also focused on the natural environment and especially other forms of sensing (by other people and animals) "we see things like this, the way we see it. But in other people, or other creatures, the insect, they might see things differently. So it might be interesting to know how other creatures see the world" [4:77]. The focus was also on science, the scientific endeavour, and it's relevance to everyday life:

> …and a lack of sense of the value of apparent whimsical activity and thought, but where is the science? [laughs] Yet, this is one of the most scientific things I was thinking, and this is… isn't this how the scientist operate? basically? but that doesn't – this is a way to see – it connects me with a bigger picture, and I see my role in it clearer. And to think part of that bigger picture and feel that connection with others is really… it adds a certain clarity to… you know, what's life is about, what's important. [2:73]

Reflective enquiry was facilitated purposefully during the playshops as part of group discussions and but analysis revealed that the interview process also served as a space for reflection.

11.2.3 Different ways

A salient experience for playshop participants was that of recognising different ways – of doing, thinking, and knowing – at the personal and group levels and the impact that that recognition has:

> …[that] my view of the world is not the only one, it's not the perfect one, there are others, who's- they don't necessarily deny mine but, just cohabit with mine. They are really deep and worthy to know more about them. [5:106]

> I've experience of other people looking at it in about 30 different ways – 30 different things to see from what I'm seeing. And, I apply that to all kinds of situations and again, before, when I'm lacking self-confidence, I realise that there isn't a right way or wrong way type of thing – there's different ways, is this – so it extends my freewill. It extends my freedom, my range of movement. And I think if that self-confidence again relating back to the authentic expression and my way is my way. [2:134]

Different ways is revealed through thought (*reflection*), action (*making*) and an interplay between both. As reflection, it is about experiencing different perspectives (of the world, of everyday life, self) and ways of connecting with people and artefacts, and sharing with others. Through hands-on/making it is revealed through different ways of doing – of communicating (through artistic expression and forms other than verbal) and of using various media to sense the environment. As interplay between doing/making and reflecting *different ways* takes shape through different ways of experimenting, extending learning and understanding.

A main consequence of engagement is realising and gaining ability to "rewire" thoughts, finding different media to experience, analyse, express, and "not reproduce meaning, but produce meaning" [5:92] as a way to "express your feelings, yeah through different ways" [4:53]:

> …it was opening up different borders too but through more physical, more sense-oriented way like going out and collecting things according to each other's theme and seeing how it grows in the water bottle or coming up with the way we can explore the world by ourselves [...] It opened up physical space too. That the same place looked different or fresher, but it's got the essence of art playshop too. Like people get into it

> and forget about time and whether judging you are doing it well or not just doing it is great. [1:15]

11.2.4 Comfort zone extended

The salient theme 'comfort zone' is linked to assumptions and generalisations – about self, others, and the identification of generalisations made by others. *Comfort zone extended* is linked to 'overcoming barriers' (discussed in 11.3) and is revealed as *aspiration*, for example, when defining 'how I want to live my life': "and that's what I want to do, I want to live real life" and not be "preoccupied with "am I doing it right or wrong?"" [2:35].

Realisation of extent, limits and existence of comfort zone is revealed through participant's 'discomfort', 'fear' (of e.g. not fitting in), ambivalence, contradicted expectations, and frustration from engaging outside of what we are used to because "we're so used to our patterns" [2:126].

Analysis revealed that extension of comfort zone has many requirements: accepting there are different ways; having a change in 'attitude' and 'frame of mind' (explained in more detail below); *courage* and realisation (reflective thinking) – being 'honest' and comfortable with 'revealing' oneself; ability and willingness to "force myself" or "you have to challenge yourself, you have to challenge your creativity […] inspire each other and explore our potentials" [4:6, 4:10]; and identifying the 'rules of the world' and ways to break them. Extension of comfort zone is also shaped by past experiences as frames of reference that mark 'transformation' e.g. childhood experiences or memories from initial steps in engagement in playshops (explained in 11.4).

'Extending comfort zone' also requires a *relaxed* and *playful* workshop environment that provides a space to explore things that could not be explored elsewhere (see Figure 11.3). Linked to 'frame of mind', it requires an ability to create new meanings "it's mainly about attitude" [3:109] and relationships to artefacts and conceptions (e.g. art and science):

> But science is finding out - to try to attain the closest approximation of reality that we can through empiricism, through observation and experiment. And isn't that what we are doing because we're not doing it with white coats on because we're not doing it in some institutional type of setting we don't think its science – it's something that other people do. And only other people *can* do… it's a cultural blind spot I think. It's a neglect

of something, which would be better and more- healthier for the individual and society if we had a culture where creativity was part of our day-to-day existence. And using the word 'science' may be a bit inhibiting in fact, until people get used to the idea that we're here to be creative. [2:84; 2:48]

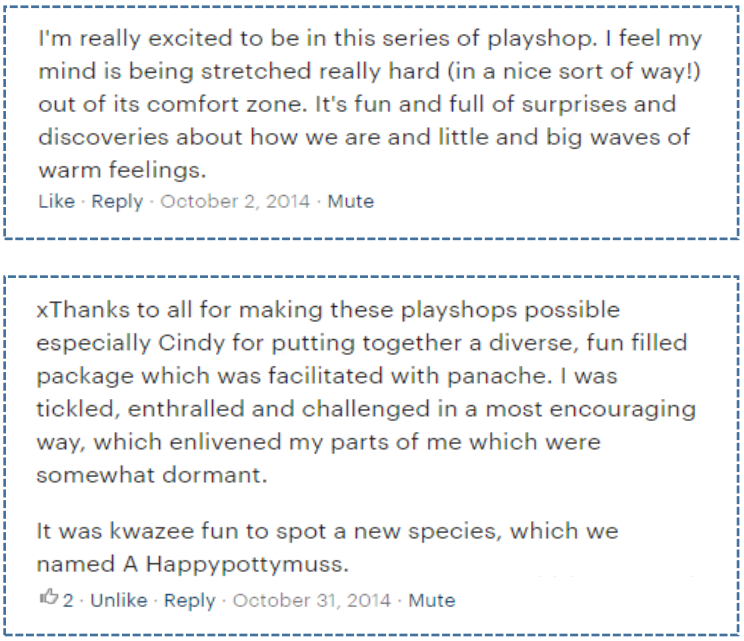


Figure 11.3 Participants' comments on playshops' webpage.

11.2.5 Interplay between consequences & conditions

One of the most interesting results from theoretical sampling (intense analysis around one category in terms of the 'coding paradigm' to saturate it) is the relationship between *conditions for-* and *consequences of engagement*. While initially it was difficult to differentiate between the two, further analysis revealed that the relationship is one of interplay. There is reciprocity in that as participants engage in the workshop environment they built new connections or frames of reference from different ways of seeing/doing that lead to curiosity and enquiry. These in turn become a condition for continued engagement: "And that's another question if we do it again how I do it with different objects, why did I feel weird? What's blocking me? […] And yes I want to do it again" [1:62]. *Enjoyment*, a consequence of engagement, in turn becomes a *reason for engagement*: "if I used to come to the playshops or workshops it was because I was trying to feel- to have a good moment again" [5:113]. *Conditions for engagement* in DIY enquiry at the level of workshop environment become *consequences of engagement* – an environment with complex interactions that is perceived as both engaging and safe promotes

continued engagement: "I felt it was a safe place, [...] it lent itself to revealing it, revealing-once I felt "I am revealing myself here"" [2:21].

The relation between consequences and conditions for engagement is at interplay at the personal and group levels. This interplay is also revealed through *barriers to engagement*, discussed next.

11.3 Theoretical sampling: Barriers to engagement

As seen in Table 11.3 comfort zone and engagement are the main categories linked to *barriers to engagement* and operate within the personal and workshop contexts. The most salient subdimensions linked to it are *staying within comfort zone* and *condition for engagement*. While interrelated, 'staying within comfort zone' addresses the range of barriers whereas 'condition for engagement' the ways to overcome them. Figure 11.4 maps the themes and insights into barriers to engagement.

11.3.1 Staying within comfort zone

Barriers to engagement are manifested within the *personal sphere*, through *interactions with others*, *artefacts* and the *workshop environment*, and are framed at the social level. There are also several external and practical aspects that act as barriers to engagement.

At the personal level analysis revealed *expectation*, *judgement*, and 'frame of mind' as barriers mediated by 'past experiences'.

Expectation and *judgement* as barriers emerge as inhibitions at the personal level in interaction with others: concerns for others' opinions linked to a need to please others, scepticism, lack of belief in self and perceived lack of creativity:

> I think my flock mentality kicked in. I was actually trying to impress everyone through what I was doing and probably that's why they didn't end up – for me the experiences weren't as good as they could have been. [3:69]

> …to think "oh, what! This can't lead anywhere, can it? I have more important things to do" [2:72]

Table 11.3: Categories and their subdimensions (or subthemes) linked to the salient theme *Barrier to engagement.*

Salient theme (groundedness)	Category	Subdimension	Co-occurrence	Co-occurrence frequency
Barrier to engagement (52)	Comfort zone	Staying within comfort zone	23	0.22
	Context	Personal sphere	32	0.20
		Workshop environment	20	0.10
	Engagement	Condition for engagement	22	0.14
		Consequence of engagement	19	0.09
	Frame	Frame of reference – judgement	16	0.13
	Interaction	Interaction with others	15	0.12
	Knowledge	Reflective thinking	13	0.10
	Medium	Artistic expression	16	0.10
	Response	Issues/sense of connection	11	0.09

As with *comfort zone extended*, *staying within comfort zone* involves awareness about the extent of your comfort zone to avoid taking 'risks', uncertainty, and vulnerability. It is a 'frame of mind' "because sometimes you went into a workshop and you felt like… "mmhh… I'm not sure", and you know, there are some kind of burdens in your mind" [4:30]. For participants playshops were about 'extending' that comfort zone through their own experience and reflection:

> And by doing it, my habitual way of thinking, fear of judgment by others or how I come across as a worthy person to the group, it's changing because I shared it with people and before I wouldn't want to share- I wouldn't risk sharing it. [1:92]

Through *interaction with others* barriers to engagement arise from 'pressures from peers' and 'not connecting' with others: "If I don't feel connected, I feel like marginalised, even if I am there" [5:89]. Peer-pressure works both as barrier – "it creates a pressure on me "Oh, and they are testing me so I need to [make] an impression"" [5:108] and as a way of overcoming barriers with "enthusiastic fellow playmates" (see [2:74] in 11.2.1). In terms of *interactions with artefacts*, *staying within comfort zone* is framed in terms of expectations/preconceptions and attitudes about: a) outcomes – e.g. a wide range in art, binary in technology; b) initial personal feelings and inhibitions; and c) aptitude and trust in that aptitude – soft (e.g. taking on challenges) or hard (e.g. technical/scientific skills):

So in the artistic [playshop] I will not say "oh you need to know about art", no. But in the explorer [playshop] I will say "you will enjoy that more if you know some things- if you have read and if you really..." [...] if you know about science you will enjoy even more. [4:149]

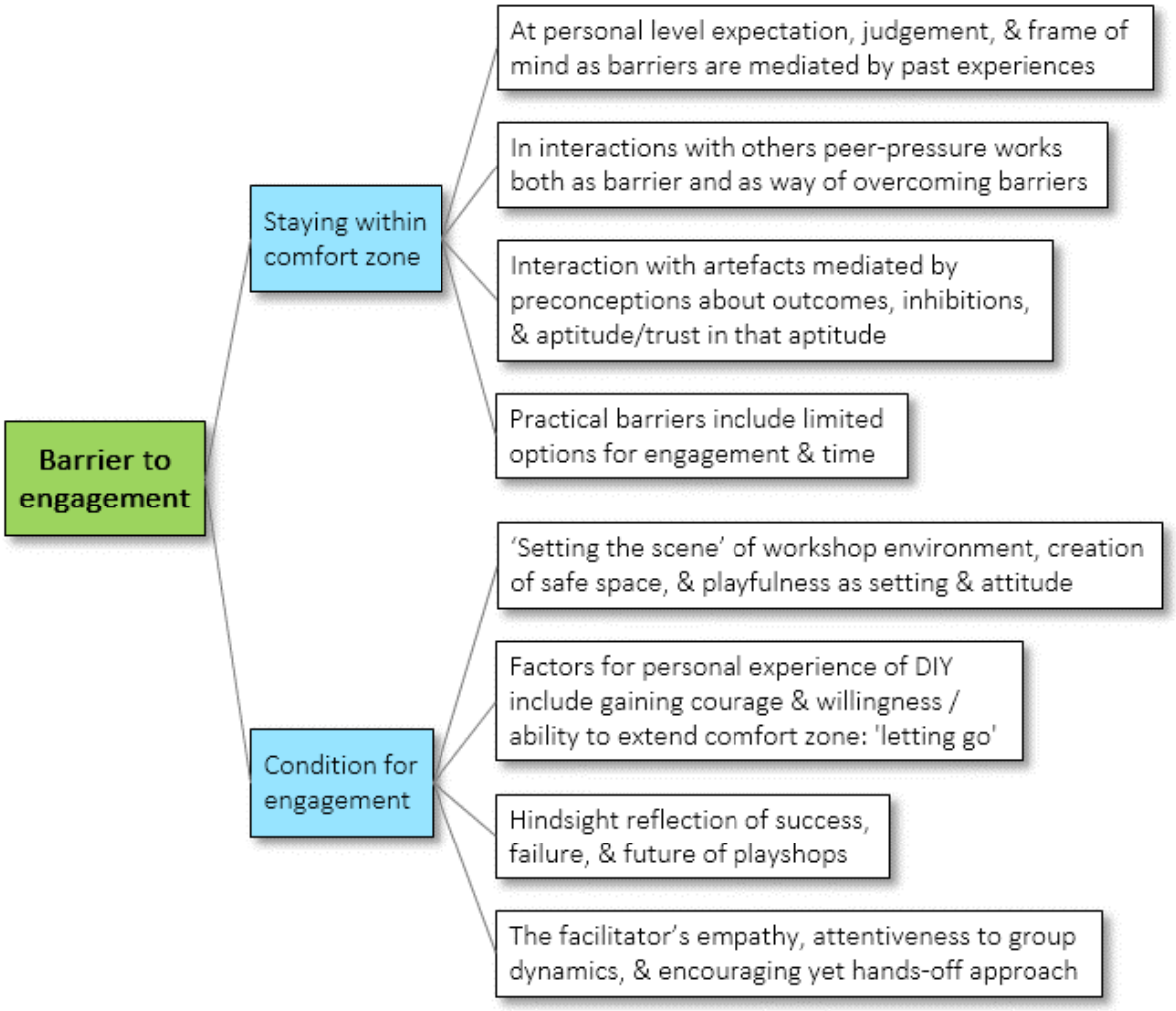


Figure 11.4: Theme map for 'barriers to engagement' in DIY enquiry through playshops.

'Socially framed' barriers include cultural and social pressures, "those rules" [4:36], for example, social inhibitions to engaging in enquiry using our senses such as smell, touch, or taste:

…it's a cultural aversion to licking something that you do not know where it has been, and I'm really glad he overcame that and just did that. And that showed a real basic curiosity, right? Which is curiosity, I think, is linked to enquiry [3:10]

An important insight was that 'past experiences' such as positive or negative experiences in childhood or in previous playshops frame *both* the barriers to engagement *and* the ways to overcome them: "You might have felt like some playshops were more amazing than others but they wouldn't have been as amazing if you hadn't had the other one" [3:122]. In addition, the workshop itself can be a barrier. In one instance, the workshop setting is described as 'academic' and therefore, not allowing for 'political views' to be expressed.

Analysis revealed several 'practical' barriers to engagement. A participant summarises them:

> It could be that what they created wasn't valuable to them in the same way that what I created, was valuable for me; now it could be a couple of reasons for that. It could be the options available for that self-expression were too narrow. It could be that the time given for engagement wasn't enough or wasn't in the right setting. There may have been better off going first into the forest rather than the classroom. And it may have been that it was daunting to reveal one self and perhaps they were pretending and that's always stressful really, it's not enjoyable, to act - you have to concentrate on the act rather than – "that's just my – that's my spontaneous response to that". It could also be, of course, that something turned up for them, that they just couldn't make it [2:89]

Other barriers are the perceived effort needed to engage (in relation to everyday life) "because you just had a tough day or whatever, life is difficult enough" [4:104] and that due to cultural differences, a playshop cannot be replicated or 'adapted' anywhere because of the complex interplay between factors which would need to be recreated:

> …we need to reproduce the conditions to create it. Yes, if I wanted to export the playshops, […] how to reproduce the conditions of possibility of your playshop? The audience, the leader, the facilitator, the space, the background and also the communities, I think, will need to be communities with academical relationship, and capital- some scientific capital. [5:104]

Overcoming these barriers and the factors that play a role in this are the topics of the next theme.

11.3.2 Condition for engagement

Conditions for engagement as 'ways to overcome barriers' are revealed through the *workshop environment* and experiences of DIY (*defining process*), 'reflective' capacity, and the role of the facilitator.

A key insight from analysis was that experiential learning, building a relationship with space, continuity of playshops, 'setting the scene' coupled with creation of 'safe spaces', and 'playfulness' (as an attribute of the setting and as a personal attitude) are *conditions for engagement* to overcome barriers in the workshop environment.

The 'safeness' of the space is described in terms of focused directed engagement with elements of playfulness and fun [as seen in quote 2:21, p.249] that 'set the scene' of the playshop coupled with dedicated time for feedback.

'Playfulness' is revealed as an attitude: "you can create one and you can be in it, even though during work" and as a 'situation' created by interacting with others:

> I think the playfulness of it all, now we've set a new set of playshops with creating the scene and all of the stuff but they are on the same lines with making use of what you've got around you, using your imagination and creating playful situations [3:119]

The conditions for *playfulness* are *trust*, *embracing vulnerability*, being willing and able to 'extend comfort zone' "first it was like, "What the hell?!" Yes, but two minutes later I changed my mind, like, "Okay, that's fine"" [6:116]. While it seems to be aided by artefacts that facilitate exploration – such as 'goggles of enhanced perception' or magnifying glasses, Lego, materials scavenged in the forest, etc. – *playfulness* is mostly conceptualised as using imagination to create immersive situations that inspire others.

Conditions for further engagement stem directly from relevance to participants' own lives. Combined with an expressed desire to 'know yourself better', 'reflection' coupled with gained awareness of other's perspectives/judgements also reduces barriers to engagement.

Descriptions of DIY experience (*defining process of engagement*) reveal what engagement in DIY means for participants e.g. reawakening the 'inner maker': "It's not just about exploring the world, it's also about exploring yourself, like looking inside and finding the things that we …

you know, myself have neglected since our childhood, […] like you know, the creation of things" [4:2; 4:4]. It is about experiential learning through observation and figuring things out (discussed in 11.4.1) infused with a feeling of "I just forgot time existed" [3:100] as well as forgetting about judgement or doing it right or wrong "I like the free play, I like the flow" [2:4]. This is akin to the dimensions of 'cognitive absorption' described by Agarwal & Karahanna (2000).

The conditions that enable these experiences of "curiosity or just letting go of yourself more and more" [1:113] are a personal ability to "daring to do as we wanted" [3:128] – or gaining *courage*, especially during the initial stages of engagement (discussed further in 11.4). Linked to this, it is interesting to note that the themes *science* and *science activities* did not have high occurrence in the data (Table 11.1) because, as one interviewee notes, the DIY experience is more about *connection* and *aspiration* than about 'material stuff':

> That conveys how I want to be with my life, with our lives because that's to do with not creating the material stuff but it's how we connect through art, connect with each other, connect with ourselves tapping into how we want to see the world, how we want to deliver us to the group and how we want to create the atmosphere there as a group […] But as it was with me, it needs a lot of courage and opening up. [1:116]

A condition for sustained engagement is 'reflective capacity'. For example, participants compared and reflected on what worked and did not work through 'hindsight' reflection on judgement and enquiry, and wondering how that they have experienced can be taken to "a wider society" [1:182] and making it sustainable by "creating facilitators, so others can facilitate" [3:112].

The analysis revealed that the role of the facilitator as *condition for engagement* is framed in terms of the characteristics they possess: "the facilitator has to be very intuitive and be able to listen and […] should be … have some sort of ideas about the objectives […] something that we need to achieve" [4:87]. Additionally, they need to be attentive especially when participants are extending their comfort zone:

> We have an idea and we have questions through- when we are confronting the idea with the reality with experience – "Okay, that was what I didn't imagine that at the beginning…", so the facilitator needs to create- to answer questions, to change any things that need to be changed in order to keep people in the game [5:44].

Barriers to engagement are revealed throughout the engagement process. However, it is through experiences at the 'initial stages of engagement' that factors affecting the development of engagement are most evident. I discuss these next.

11.4 Theoretical sampling: Initial steps to engagement

The main categories linked to *initial steps to engagement* are 'activity', 'engagement', and 'medium' (Table 11.4). *Initial steps* is strongly associated with the 'workshop' and 'personal' contexts and the frame of reference 'judgement' and its salient subdimensions, discussed next, are *making*, *artistic expression*, and *reason for engagement*. Figure 11.5 maps these themes and insights from theoretical sampling.

11.4.1 Making

In the playshops *making* involved coming up with ways of sensing the environment, experimenting, and giving material representation to experiences of DIY. Analysis reveals that *initial steps* in *making* are manifested as a process of 'letting go', experiencing a 'lack of frames of reference', and 'creating new frames' to express and/or make sense of experiences of DIY enquiry.

> I forgot, long time ago- I forgot about how playing was really to begin with. I forgot what it is like, but after the first one and the second playshop, I got really into making. That one hour or one hour and a half or sometimes shorter, that time, I forgot about time, I was really into that moment. [1:100]

Table 11.4: Categories and their subdimensions (or subthemes) linked to the salient theme *Initial steps to engagement.*

Salient theme (groundedness)	Category	Subdimension	Co-occurrence	Co-occurrence frequency
Initial steps to engagement (26)	Activity	Making	15	0.20
	Context	Workshop environment	20	0.19
		Personal sphere	13	0.08
	Frame	Frame of reference – judgement	14	0.16
	Engagement	Reason for engagement	11	0.13
		Defining process	7	0.11
	Medium	Artistic expression	11	0.12
	Comfort zone	Comfort zone extended	8	0.11
	Response	Challenge	4	0.10
		Issues/sense of connection	10	0.09

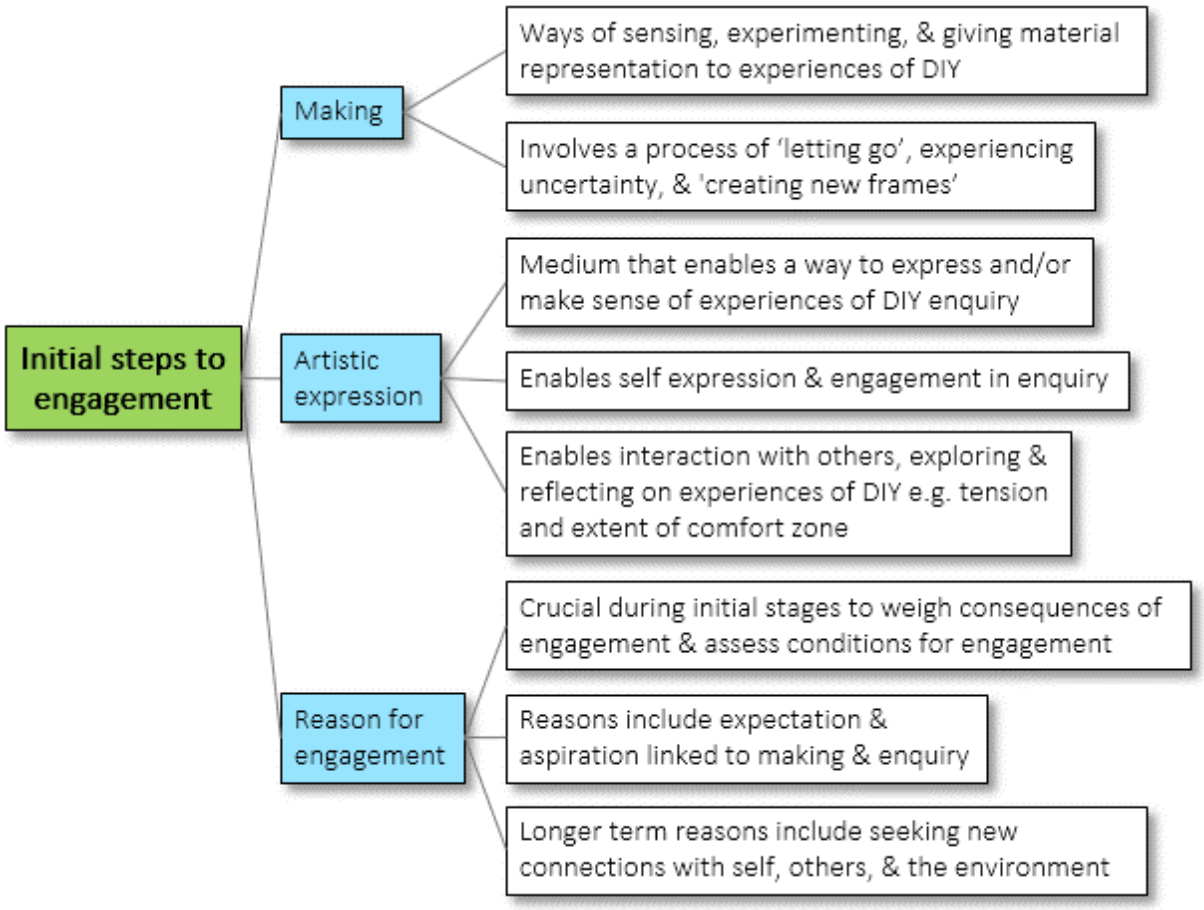


Figure 11.5: Theme map for 'initial steps in engagement' in DIY enquiry through playshops

Initial steps in *making* are framed in terms of 'judgement' and 'expectations' from/about self, others, and, surprisingly, to a lesser extent, artefacts. These framings include uncomfortable experiences such as 'fear of being honest' with oneself: "It was new but it was a fear of – not judgment, but like of being honest. It was in a way quite scary. […] I guess I wanted to make something pleasant and something for them to talk about and something to show that I'm intelligent […] I wanted to show that I understand something, something meaningful I can say" [1:10]. Initial 'judgement' and 'expectations' can be a barrier to *making* but continued engagement from wanting to overcome that barrier leads to *making* that exceeds expectations:

> I didn't attend all the sessions the second time but… I think it did kind of give me some kind of confidence and some kind of assurance I think, because last time … the first time when I did the workshop, the last session was to create something using the objects that we collected and I didn't even complete it. But the second time I did it, I created actually two objects, yeah. I'm not saying they're great but I think I'm proud that I was able to do that, yeah. So yeah it helped definitely. [4:43]

This also reveals an important initial step: developing an ability to 'let go of inhibitions' and 'just start'.

Initial steps in engagement are also characterised by uncertainty stemming from 'being confronted with new' situations e.g. engaging in DIY making and with new perspectives. *Making* with strangers in a workshop environment is described as initially "uncomfortable and certainly we don't do that thing every day" [1:1]. Sharing ideas and reflections with others in a new context also leads to ambivalence and with the initial reaction of wanting to *stay within comfort zone* (11.3.1). Initial steps are characterised by a strong and defining struggle between capitulating to and overcoming barriers: it is a change in framing mediated by hands-on experiences, interaction with/expectation from self and others.

Initial steps in engagement are also manifested as participants seek ways to connect and/or create new frames of reference through *making* and specifically DIY making through *artistic expression* (explained next). This adds an additional dimension of interpretive interaction (Figure 11.6) in which *connection* is a precondition for engagement because *connection* requires the creation of 'new' frames of reference – expressed by participants as *extending comfort zone* (11.2.4).

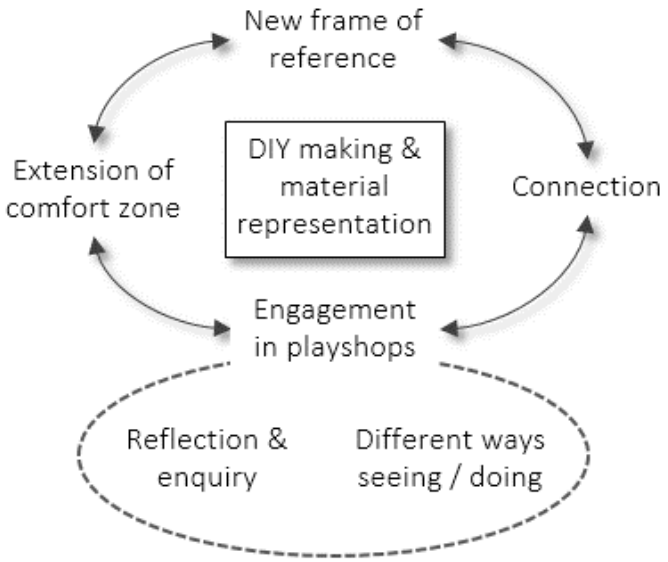


Figure 11.6: Dimensions of DIY making and material representation.

In these playshops it is interesting that even those participants with backgrounds in science and technology explored new frames of reference and transcended enquiry-related barriers to engagement. One participant expresses the value of engaging in the process of DIY making:

> …my sort of conclusion to this would be, if playshops can get more people interested in science, non-scientists or scientists to do this kind of really open-minded enquiry during other parts of the day or just do it more whenever, on top of their other obligations in life, that can only be a good thing for science [3:98]

11.4.2 Artistic expression

Artistic expression was used in the playshops as a medium to interact with others, to explore and *reflect* on experiences during the playshops, to engage in *enquiry* and express its process, to explore tensions, and to give material[24] representation to experiences.

For all participants *artistic expression* stimulated *enquiry* and *reflective thinking* about relationships with self, the environment, and society. For example, enacting how a plant grows and how it is affected by its environment: "I think it makes you enquire about your own ability to decide your future, your own existence" [3:81]. While the workshop environment provides a

[24] By the end of the playshops there was also narrative expression. See end of chapter for 'Ode to playshops'.

safe space for reflection and *sharing experience* (explained in more detail in the next section), artwork, and the process of making of it, also mediates ways to express those reflections.

In this way both *making* and *artistic expression* are linked to various dimensions of the workshop environment. For example, the playshops are described as having 'politics' and creating tension between enquiry, 'prying', and connection: "[playshops] are political in the sense that- because they create conflict with you- because at the same time that they are trying to understand you in some way, to speak with you, obviously they also want to know why" [5:124]. In this sense, artistic representation was seen as a "way of expressing my mental movement" and 'mapping enquiry' and recognising production of knowledge (see [1:150] p.261].

Playful interaction with artefacts and engagement in artistic expression also play an important role in engagmenent in *enquiry* during the initial steps of the playshops. For example, playful interactions with artefacts such as 'distortion goggles', oversized magnifying glasses, DIY hearing cups used during the first playshops both lower barriers to engagement and promote engagement in enquiry. They create both playful and frustrating experiences that lead to further enquiry. An interviewee describes the process of giving artistic representation (using stop motion animation Figure 11.7) to the experience of 'hacking' and the use repurposed electronic equipment.

> Interviewee: Animation was fun, wasn't it? [laughs] That was really pure fun but I was surprised how it was hard to open the computer. I wanted to just throw it out of the window and smash it.
>
> Interviewer: It was meant to not be opened! [laughs]
>
> Interviewee: Yes looks like it and why? I think for me personally, and maybe other people too I don't know, it made me see things really well and I started to ask why more often about computer maybe after that one. Because nowadays it's just easy to just follow computers. They… When you have a new phone or computer, when you plug it in they started to ask you "hello", and then you're just "yes" or "no" or "yes" or "no". And then now it's setup, ready for me and if I don't know what they're asking, I just say "agree", "agree", "agree" right? [laughs] But it's not about the interaction like that but - what it does for me, why I want it to function that way, do I really need this function? Why… How does this… I got this function but how does it work? It looks like a little phone but what's GPS going from where and it's in my pocket? Is it going through my body or kind of thing. It just made me ask more questions. And that makes me sometimes uncomfortable because you can't really get answers. [1:32]

Artistic expression is a key factor in engagement in the playshops because, as discussed in Chapter 5 argument-by-discourse, whether it is written or verbal, it conveys something about how taking ownership, experiencing self-reliance, self-learning, and self-satisfaction takes shape (see 'Ode to playshops' at end of chapter). This confirms Kelty's (2005) idea of 'argument-by-technology'; through artistic expression DIY provides a voice that not only gives material representation to the individual developmental journey of engagement in DIY but also shapes the collective process of empowerment and transformation when the experiences are shared and reflected upon. This transformation is discussed in 11.5.

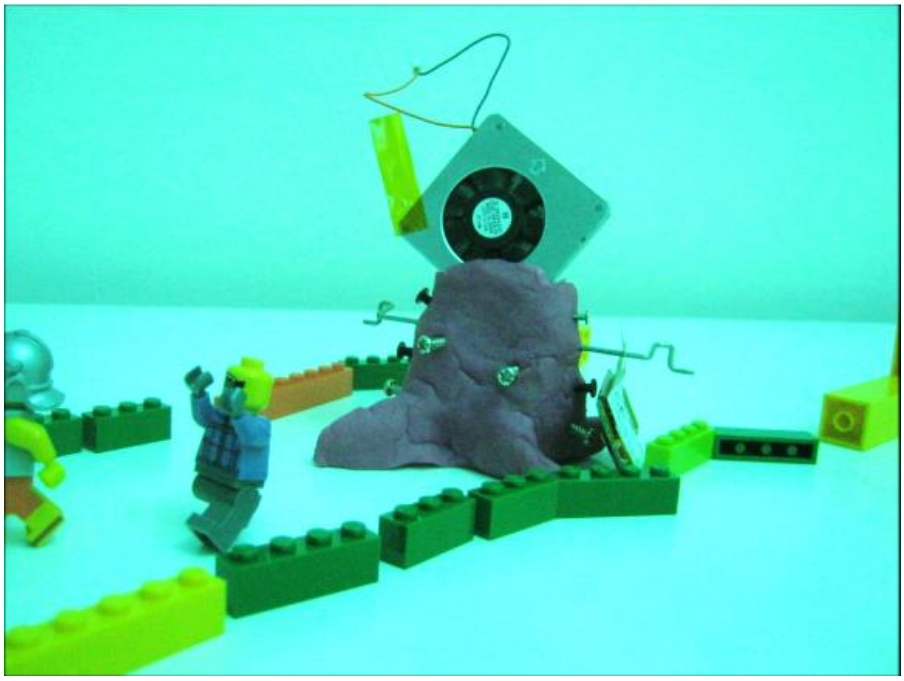


Figure 11.7: Frame from an animation video produced at a final playshop: "The arrival of the Singularity". The 'technological singularity' is made from repurposed computer parts.

11.4.3 Reasons for engagement

Reasons for engagaement are revealed throughout the case. However, the *reasons for engagement* at initial stages of engagement mark a turning point in engagement. They occur within the personal sphere when reflecting on (or defining) the process of engagement, where people weigh the *consequences of engagement* and assess the *conditions for engagement*. *Reasons for engagement* include *expectation* and *aspiration* linked to *making* and enquiry. Reasons for continued engagement also include seeking new *connections* with self, others, and the environment, as exemplified in this quote:

> I don't know if that was with other people, and when we did that and improvisation theatre thing, with that plant thing that was to observe plants in our head and then try to externalise it. That was a bit weird experience and I want to do more of that because I couldn't quite get what I got out of it – I was too "what I'm I doing?" I couldn't connect it very well but that was the start, right? It made me, "oh, there is that kind of way of expressing my mental movement" [1:150]

Seeking or building connections with others – and how that creates an inviting environment – are also revealed as *reasons for engagement*. It also opens up a realisation of potential:

> if you do it on your own, it wouldn't have been like that but we are doing it as a group. And I saw it – I saw our group as mini society […] If that's the way you want to interact with people, I can. If you want to communicate with people that way, I could." [1:89]

11.5 The nature of knowledge & transformation in playshops

The analysis reveals that spaces and opportunities for engagement are co-created and involves the creation of common rhetoric and practices. Shared and co-created situations 'demystify' engagement in enquiry and technology, promote curiosity and playfulness and elicit both *frustration* and *joy* in a process of understanding and engaging with others and the world in their own (rediscovered or newly created) terms. I have discussed this in the journal article "Promoting playfulness in publicly initiated scientific research: for and beyond times of crisis" (Regalado, 2015).

Co-created spaces in the playshops also aids in building tacit knowledge. Two main factors are at play: 1) the process of experiential learning, which builds connection and meaning and through that, the ability to overcome barriers to engagement, and 2) having playshops sequentially, which supports continuity of experiential learning: "I enjoyed all of them actually and I'm looking forward to [...] attending more" [4:90] "And looking forward to going deeper [2:17]". The nature of the tacit knowledge produced is revealed as the interplay between *conditions for*- and *consequence of engagement*: as participants engage and build capacity in exploration/enquiry, it enables to seek new challenges in exploring different ways of 'rewiring things' and giving them material or symbolic representation. Evidence suggests that the outcomes of the playshops are highly dependent on the facilitator and the context within which the playshop are developed and unfold, as seen in quote 5:104 (p.252).

Analysis revealed that all participants experienced a 'change' as a consequence of their engagement in the playshops. This change occurs within the *personal sphere* and the *workshop environment*. Consistently linked to *interaction with others*, *different ways of seeing/doing*, *comfort zone extended*, *initial steps of engagement*, *courage*, *issues/sense of connection*, facilitated by media such as *artistic expression*, and framed in terms of *judgement* 'right or wrong', the nature of this change is one of *transformation*:

> I do think that being able to share this, what we shared with others helps you to be more at ease with yourself, and it probably helps you to get the guts to speak up for what you believe in or what you think about things. I mean I've seen a huge transformation in some other people, and I think I've seen small transformation in myself. I feel more comfortable being who I am I guess and certainly if we look at [NAME], for example, s/he's really amazing. [...] So one of the main borders that we crossed was one of self-esteem or of, yes, courage. [3:45]

> It was really ground breaking for me to… how we can connect and – I don't know if…okay we can connect this- another speculation- *did* we really connect? We don't know but the way we communicated, that's for sure and that way of communicating is ground breaking and so it destabilized my preconception about communication and I think that we shared and that's really good. And to me personally, it's really ground breaking because to realize that I'm not stable, that there is no truthful real me. But I'm almost us. It sounds a bit wacky or New Age, but like other activities in Citizens without Borders too… [1:176]

> [C]ertainly the relationships with other objects, other phenomenon, other things is more tangible. It's definitely more tangible. So that interconnectedness is very real for me, and I'm part of it, and being acutely aware really of the change in nature of everything, which everything is changing, where's it coming from, where's it going, is something which I have engaged with and find it quite a positive vibe to engage in this like an energy and it's flowing, and several times in the artshops, I lost the sense of time, and that's a definite indicator to me that I'm in the flow, and then I'm really alive, and that's what I know, the highlights of it for me. I got a great sense of aliveness; but linking up to what I said before, it's being very confidence building in me, because I think in the past, I've tended to look for what is the right way and the wrong way to behave. [2:20]

In the next section I present the substantive theory on public engagement in DIY enquiry through playshops; the results from the theoretical sampling presented in the sections above are integrated to highlight the relationships between salient themes and subthemes. In doing so, I also review my initial propositions and model presented in Figure 11.1 (p.236).

11.6 Integration and core concepts

Figures 11.8 and 11.9 illustrate the Grounded Theory for the case study of public engagement in DIY through playshops. I would like to emphasise again that, grounded on the data for this case study, the theory is specific to the phenomena in the playshops.

The Grounded Theory of engagement in playshops is illustrated in two parts: the interplay between *workshop environment*, *personal sphere*, *social context*, and *conditions for engagement*, and a zooming in into the *consequences of engagement* portraying what *interactions* mediate and are mediated by.

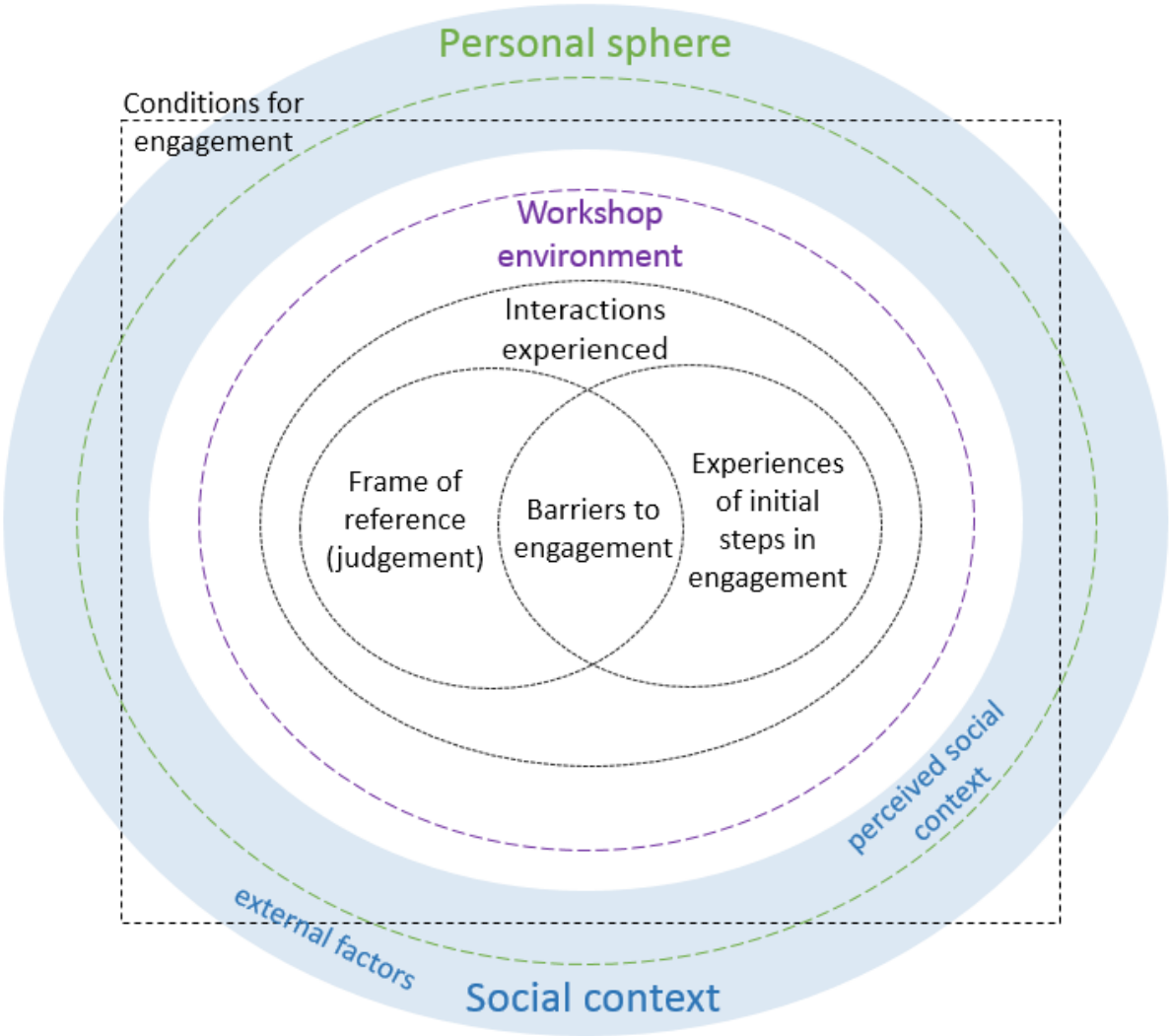


Figure 11.8: Grounded Theory for the case study of public engagement in DIY through playshops.

Looking at the first part of this model, Figure 11.8, it can be said that playshops unfold within the *workshop environment* (purple dotted line signifying the fluidity of the experience). They simultaneously occur within the *personal sphere* (green) and a *social context* (blue). The social context consists of both that which is perceived by the participants (within the personal sphere) and external factors (outside the personal sphere e.g. other people's lives or events such as a tube strike impeding participation). Concomitantly, the *conditions for engagement* in the playshops range from those within the personal sphere (e.g. frame of mind) to external factors (beyond those captured in this case study).

This model also shows that the *interactions* experienced within the *workshop environment* are predominantly framed in terms of *judgement*. Interactions are also shaped by and conveyed through participants' experiences during *initial steps of engagement*. Additionally, *barriers to engagement* are at the intersection between *judgement* and experiences during *initial steps* of engagement.

The second part of the model in Figure 11.9 takes a closer look at experiences within playshops – that is, the interplay between *consequences of-* and *conditions for engagement* represented by the blue wave and black dotted line. The focus is on the process of *interactions* – with self, other participants, artefacts, and space/environment. Represented as dotted lines, *interactions* are also fluid and they are mediated by and/or mediate *different ways of seeing/doing*, *extension of the comfort zone*, and the triggering of/engagement in *reflective thinking* and *enquiry*. These interactions also elicit responses of *appreciation*, *courage*, and sense of *connection*.

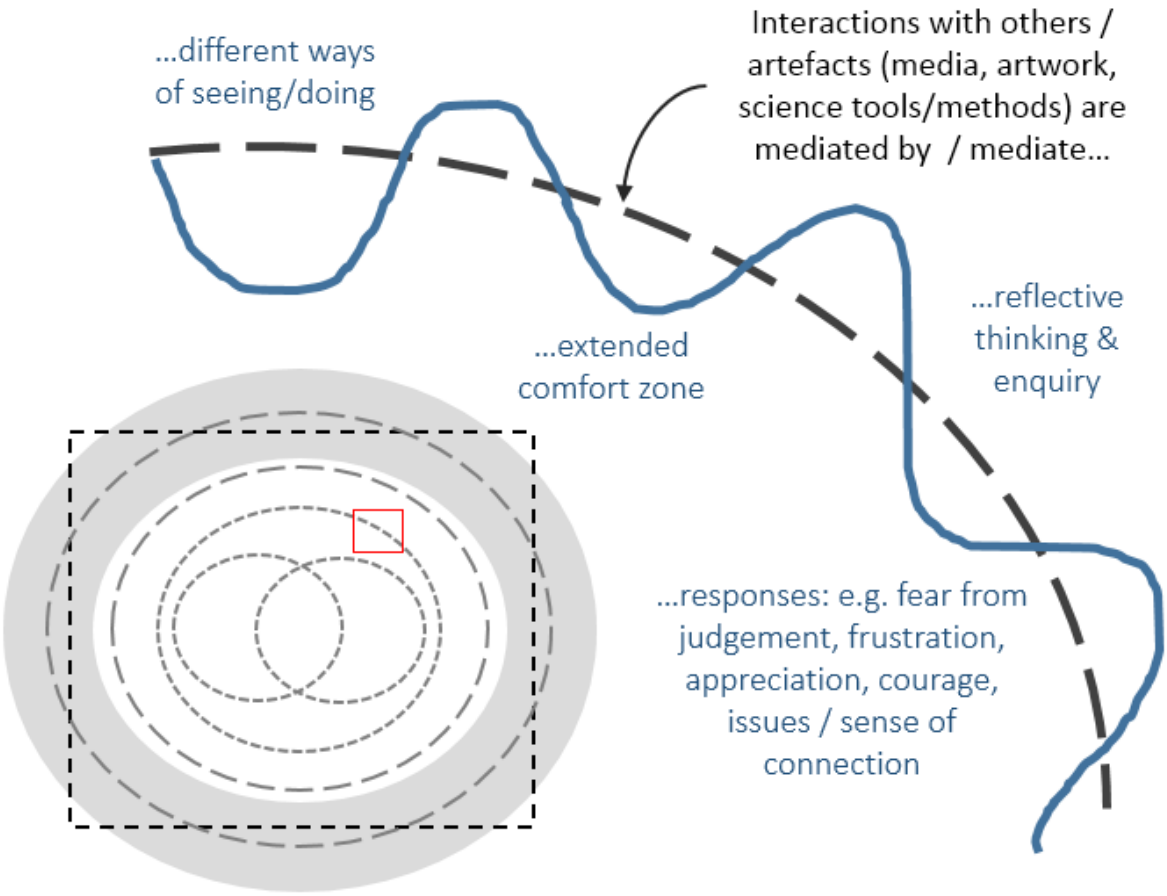


Figure 11.9: Inner part of Grounded Theory model for playshops: consequences of engagement.

11.7 Case conclusion

11.7.1 Public engagement in DIY enquiry through playshops: review of propositions on engagement, trust, and community

I now turn to a review of my initial propositions of engagement in DIY enquiry presented in section 11.1.1 (p.234). The revised model is presented in Figure 11.10 (p.267).

Engagement

The first initial proposition was that gaining 'trust' and 'courage' are essential capacity building skills and that they are also conditions for continued engagement. While trust and courage did emerge as categories linked to condition for engagement, continued engagement was more a product of a) workshop setting and design: 'sequential workshops' that facilitated

prolonged engagement and provided new or continued 'challenges', and environments for enquiry and reflection; b) *aspiration* and *connection* as *reasons for engagement*; c) *Interactions* with others, artefacts, and the setting; and d) workshop facilitation – the way the workshop is guided and communicated, and contents selected and how the facilitators is perceived. These are in fact the enablers of engagement ('Engagement' loop in Figure 11.10). In addition, it also became clear that determining the extent to which participants 'build capacity' requires longer term study and the use of tools for evaluation (as those now being developed as part of the evaluation work package in the 'Do It Together science' (DITOs) EU H2020 project, which I help coordinate using insights gained here).

Enablers

I also proposed that participants are their own enablers to engagement – that is, they build their own capacities. However, as seen above, while the nature of DIY is one of self-drive, self-enablement does not happen in a vacuum; it occurs within a workshop environment that facilitates both interactions and spaces for reflection on the experience of engagement, and is influenced by external factors – and this exemplifies the value of a micro-/macro-analysis and a constructivist-interactionist approach (section 6.6, p.132). In this environment the process of engagement does lead to building courage and ability to do, to question, and believe in that their engagement matters; this is at the heart of *reflective thinking* and *enquiry*. As above, determining 'capacity' requires further research.

Third, I proposed that self-directed engagement can be facilitated and that engagement with tools and techniques of science lead participants to pursue their own investigative explorations. Through the analysis I found that while participants engaged with various techniques and that they did pursue their own investigative interests, these were mostly focused on exploration of the self. Reasons for these need to be investigated further but based on current data, I assume that it is because the main medium for expression/representation of DIY experience in these playshops was 'artwork' (by request from participants), which is highly personal in making and in meaning. Further research should focus on ways to connect meaning creation and focused investigative pursuits.

Figure 11.10: Revised conceptual model on engagement in DIY enquiry through playshops

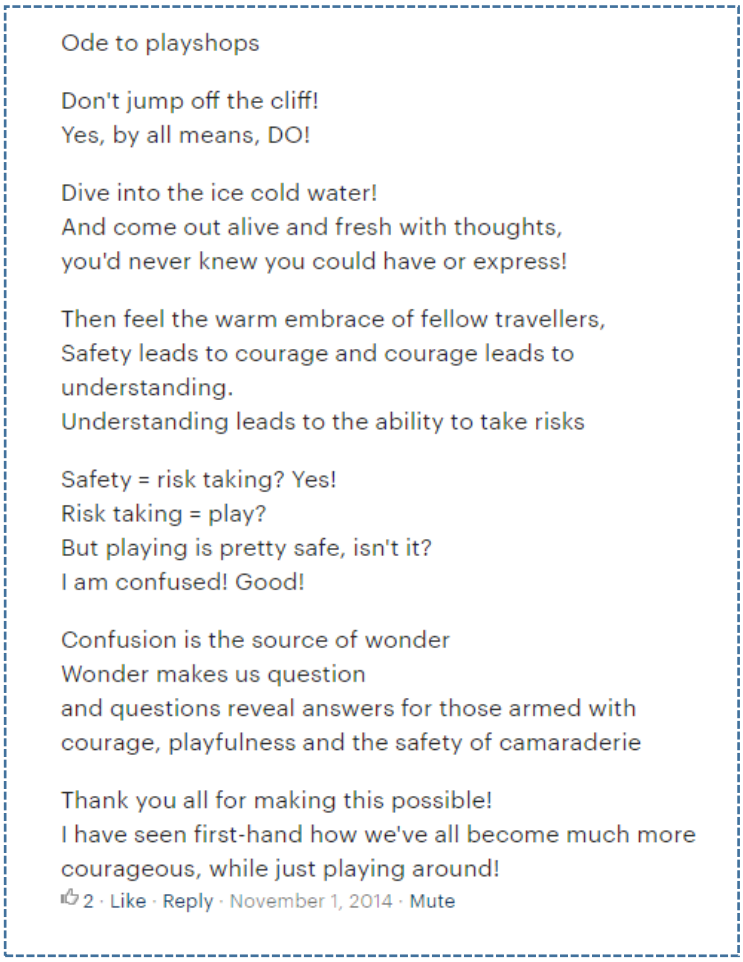
Community

Fourth, I proposed that communities of practice develop through peer to peer interactions thus, they reduce dependence on 'external' facilitation. Wegner et al. (2002) describe communities of practice as groups who share, do, and learn together through regular interaction. In the case of the playshops, continued engagement was possible because these occur within an established group. Peers within the group reflected on ways to extend the workshops – its content and access to other potential participants ('group thinking' in Figure 11.10). However, while some initiative-taking is evident with individual participants now leading their own engagement initiatives within and outside of Citizens without Borders, it is too early to tell what shape a collective or 'community of practice' could take and what kind of continued support they need. As discussed earlier it remains to be seen if the playshops themselves can be replicated elsewhere. However, I have observed aspects of the playshops being adapted by participants in their own work (arrow exiting 'Community' loop, Figure 11.10).

Lastly, I proposed that both the personal and the institutional levels play a role in creating conditions for engagement. While the role of institutions was not salient in the data, the role of facilitators does play a role – as enabler or hinderer – because it is closer to the 'personal sphere' and 'workshop environment' experienced by the participants. As with the first proposition, conditions for engagement are several and are influenced by a complex interrelation of experiences, responses, and frames of reference within the personal sphere and the workshop environment. Hence, the Grounded Theory model for playshops lies at the centre on this revised conceptual model in which all concepts are interconnected, again, with considerations for both micro- and macro-structural factors. In Chapter 14 I present an updated conceptual model taking into account the analysis results from all case studies.

It is important to note that the interviews for these playshops are biased towards those who continued their participation in the playshops. Therefore the voices of those who attended only two playshops or less were not captured; their initial interactions in the playshops could reveal what these mean to them without reflection in hindsight from prolonged engagement. This is a consideration integrated as part of the afore-mentioned DITOs project evaluation.

In this chapter I have shown the results from qualitative data analysis on public engagement in DIY enquiry through playshops. I presented the analysis, results, and substantive theory of DIY enquiry through playshops as a case demonstrating the consequences of and barriers to engagement, the conditions for engagement in DIY and ways to overcome these barriers. I have also exemplified the initial stages of engagement in DIY in terms of 'making', 'artistic expression', and 'reasons for engagement'. The surprising results from this case study were the processes of engagement in 'making' as linked to the role of artefacts. Specifically, the use of artwork as an essential medium for expression of and materialisation of experiences of engagement, enquiry, and understanding. Initial steps in the playshops are also mediated by reasons for engagement. However, another surprising outcome was that these reasons are rooted in aspiration (to gain further understanding) and connection (itself rooted in meaning) but also in uncertainty and vulnerability. As people engage and overcome barriers to engagement, they reveal themselves, embrace mistakes as learning experiences and this opens the door to innovation and creativity through reflective enquiry and transformational change.



Ode to playshops

Don't jump off the cliff!
Yes, by all means, DO!

Dive into the ice cold water!
And come out alive and fresh with thoughts,
you'd never knew you could have or express!

Then feel the warm embrace of fellow travellers,
Safety leads to courage and courage leads to understanding.
Understanding leads to the ability to take risks

Safety = risk taking? Yes!
Risk taking = play?
But playing is pretty safe, isn't it?
I am confused! Good!

Confusion is the source of wonder
Wonder makes us question
and questions reveal answers for those armed with courage, playfulness and the safety of camaraderie

Thank you all for making this possible!
I have seen first-hand how we've all become much more courageous, while just playing around!
2 · Like · Reply · November 1, 2014 · Mute

We now move on to the next case study with research as observer in 'place-based citizen initiatives of DIY enquiry' (Chapter 12, case background and Chapter 13, case analysis). Chapter 13 presents the Grounded Theory for this case highlighting that stance and framing of roles plays an important part but also are shaped by the context of place. The theory also portrays the salient actions and responses taken by grassroots organisations/groups to achieve actionable goals.

12. Place-based citizen initiatives of DIY enquiry: Background

This place-based case study, the last of the three main cases in this research, represents the dimension of citizen-led initiatives of DIY enquiry in a real-world context. The previous case studies gave the background and analysis of a participant observation for a community of DIY practice (Chapters 8 & 9) and the design and facilitation of 'playshops' (Chapters 10 & 11). In this case study I move from a participatory fieldwork approach in these chapters to 'researcher as observer' to understand the dynamics of DIY as they unfold in 'place'. The case reveals the circumstances and factors affecting engagement in DIY enquiry and the complex interactions between different stakeholder groups who leverage their knowledge and stances and develop strategies and techniques to achieve their goals. This chapter presents the background information for this case study including community organisation, setting, practices, infrastructure and tools, and events analysed in this research. It also presents the case study contribution to research, design frame, and list of sources of evidence.

12.1 Environmental issues and organisations in the Gowanus Canal

The Gowanus Canal is a 100-foot wide, 1.8-mile long canal in the New York City borough of Brooklyn, Kings County, New York. The Canal is bounded by several neighbourhoods and it empties into the New York Harbour. The adjacent waterfront is primarily commercial and industrial, currently consisting of concrete plants, warehouses and parking lots. One of these lots, known as the 'salt lot' is used by the City to store road salt and it is used by the Gowanus Canal Conservancy for their composting programme.

The Gowanus Canal was embanked in the mid-1800s and used as a major industrial transportation route since. Gas and chemical plants, paper mills, and leather tanneries operated along the Canal and discharged wastes into it. Today combined sewer overflows are the main source of water contamination carrying industrial pollutants, sanitary waste from homes, and rainwater from storm drains making it one of the most polluted water bodies in the United States. The Canal's sediment (Figure 12.1) contains more than a dozen

contaminants, including polycyclic aromatic hydrocarbons, polychlorinated biphenyls and heavy metals, including mercury, lead and copper, at high levels (EPA, 2016).

Figure 12.1: Map of the Gowanus Canal with annotations of pollution sources and layer of historic hydrological features – created by local resident. [Photo credit: Proteus Gowanus]

12.1.1 EPA and the Superfund

The EPA added the Gowanus Canal to the National Priorities List of Superfund programmes on 2nd March, 2010 (see Box 3). Since then, the EPA's involvement is on two fronts: engineering works to clean up the site, and public outreach and engagement strategies.

The engineering approach consists of 'dredging' the polluted sediment and 'capping' the Canal's bed in three different segments. These segments were determined based on contamination level, geology, land use/planning, and to a lesser extent, historic and environmental considerations with input from local residents. It also involves "the construction of retention tanks to reduce the volume of contaminated sewage solid discharges from the combined sewer overflows" (EPA, 2016). Water quality is not part of

the cleanup effort as the focus is on the contaminated sediment. An EPA official states: "In September 2013 when EPA selected its cleanup decision, we included in our extensive list of evidence some Riverkeeper data on pathogen levels. Since this topic is tangential to our Superfund role of addressing hazardous substances, we did not review the data's quality" [3:17].

Box 3: EPA Superfund

Superfund is the nickname fora United States federal government program designed to fund the cleanup of sites contaminated with hazardous substances and pollutants. The actual title is 'An act to provide for liability, compensation, cleanup, and emergency response for hazardous substances released into the environment and the cleanup of inactive hazardous waste disposal sites' or CERCLA (Keyt, 2010).

This programme authorises federal agencies such as the EPA, states, and Native American tribes to address natural resource damages caused by hazardous substances. To do this, the EPA may identify the parties responsible for contamination (polluters) and either compel them to clean up the sites, or it may undertake the cleanup on its own using the programme's trust fund as well as costs recovered from polluters by referring to the U.S. Department of Justice.

The Superfund Amendments and Reauthorization Act (SARA) increased the focus on human health problems posed by hazardous waste sites, and encouraged greater citizen participation in making decisions for how site remediation would occur. The EPA also runs five-prong environmental justice strategy focused on five areas: health and environmental research; data collection and analysis; public participation and partnerships with stakeholders; stakeholder access to public information; and enforcement, compliance assurance, and regulatory reviews (Keyt, 2010).

As part of their 'community involvement' strategy the EPA encourages the formation of CAGs to "provide a public forum for community members to present and discuss their needs and concerns related to the Superfund decision-making process" (https://www.epa.gov/superfund/community-advisory-groups). The EPA states that CAGs can aid in decision-making about site cleanup as it "offers EPA a unique opportunity to hear-and seriously consider-community preferences for site cleanup and remediation" (ibid) and thus a CAG has representatives of diverse community interests/backgrounds. However, the EPA also states that "CAGs may not be appropriate for every site. CAGs may be beneficial at removal sites, particularly non-time critical removal sites, as well as sites involved in long-term cleanups" (ibid). Not all Superfund site have this type of community participation mechanisms.

Public engagement strategies include the creation of the 'Gowanus Canal Community Advisory Group' (CAG) in 2011. These groups are designated by the EPA at Superfund sites as a form of public participation to aid with assessment and stakeholder input (EPA, 2002). The stated mission of the CAG is "to be a forum for dialogue between representatives of all segments of the community about the federal Superfund clean-up of the Gowanus Canal

and other related issues of concern to the community" (CAG, 2011). According to the CAG charter, the role of the CAG includes gathering information from the community and various sources, facilitate discussion and assessing information, contribute to a consensus-based approach for decision-making and problem-solving related to the clean-up, negotiate with the EPA and Possible Responsible Parties (those who may have caused or contributed to the Canal's problems), and providing input and guidance to EPA and others (CAG, 2011; Shapiro et al., 2010). There are currently five committees including the water quality and archaeology group. An EPA official describes the communication process and composition of the CAG:

> I think mostly it's through communication, and by e-mails … through participation, because that's why we formed the Community Advisory Group [CAG], and people are … anybody can join it. And the Group has specific committees, I mean, there's a committee, for example, that zeroes in on archaeology. So all the archaeology buffs go and join it, and have things to contribute. Then there's a water-quality group, and they talk just about the water quality. And so these groups then interact with us, with me in particular, when I go to meetings, they report, and we stay at these meetings to hear what their findings – what they have to report. So that would be the way for people to… either through direct contact with me, or the community relations person, or through the group, the Community Advisory Group. It is very effective […] and people who have know-how join these committees. [5:57]

These public engagement efforts are complemented by social media outlets such as the 'EPA's Gowanus Canal Group' on Facebook and twitter account. EPA was also a guest at the 'TEDx Gowanus Talks'[25].

12.1.2 Gowanus Canal Conservancy

The stated mission of the GCC is to act as "a community-based non-profit organization that serves as the environmental steward for the Gowanus Canal Watershed" (GCC, 2016). To achieve this the GCC various projects and volunteer initiatives to create green spaces, green infrastructure (e.g. bioswales and rainwater harvesting), composting programmes, lectures and educational programmes. Their aim is to foster "ecological, business and cultural activity in the watershed" (ibid) and thus they extend their partnerships to the local authorities,

[25] TEDx events are independent TED-like events. Using the TED brand and following certain principles, anyone who obtains a free license from TED can organise one. These talk last about 10-15 minutes.

industry/businesses, and schools. The GCC was founded in 2009 and partners with the EPA, the city Department of Environmental Protection (DEP), and groups like Riverkeeper[26].

12.1.3 Proteus Gowanus

The Proteus Gowanus was an interdisciplinary gallery that operated for 10 years; it closed on the 28th June, 2015[27]. Located on the banks of the Canal, it is still home of the 'Hall of Gowanus and Gowanus Archive' - "It is the only exhibition space in New York City dedicated to the Gowanus and stands as Protean tribute to the waterway and its ever-evolving community" (Proteus Gowanus, 2015). The museum contains historical artefacts and documents, specimens, maps, and artwork portraying the history, culture, and health of the canal. The exhibits also display the different relationships industry and residents have had with the Canal over the years (Figure 12.2).

Figure 12.2: Hall of Gowanus – view of exhibition section. [Photo credit: nicknormal at https://farm1.staticflickr.com/577/23202010620_87e204c4c4_b.jpg]

[26] A non-profit environmental organization dedicated to the protection of the Hudson River and its tributaries, as well as the watersheds that provide New York City with its drinking water (Wikipedia).
[27] The space is now in use by the GCC to continue hosting the Hall of Gowanus.

One of the highlights of the museum is the "Star of the Gowanus – the official Superfund Site Sediment Sample, donated by the Environmental Protection Agency to Proteus Gowanus in April, 2011" (ibid) (Figure 12.3). The Hall of Gowanus was established in 2010 in connection with the yearlong gallery theme 'Transport'. Local residents contributed to and curated the space thereby linking it to other projects.

In its 10 years the Proteus Gowanus hosted several projects-in-residence. These grew out of their thematic exhibitions and partnerships and were characterised by "intellectual curiosity, and a desire to engage the community in their multifarious investigations" (ibid).

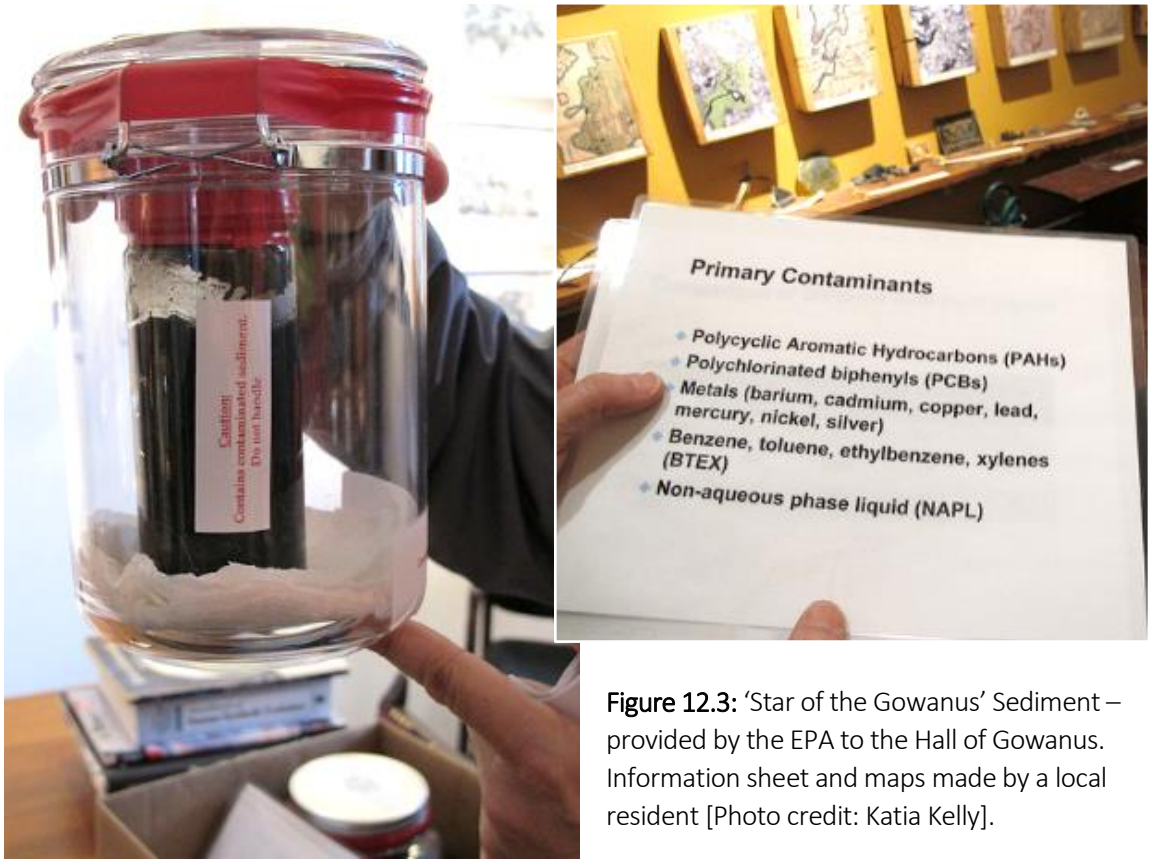


Figure 12.3: 'Star of the Gowanus' Sediment – provided by the EPA to the Hall of Gowanus. Information sheet and maps made by a local resident [Photo credit: Katia Kelly].

12.2 Citizen participation in environmental monitoring

There have been a variety of environmental monitoring efforts in the Canal – some institution-led, others grassroots. Institutional-led initiatives include the 'Brooklyn Atlantis' project, a monitoring system employing a robotic aquatic vehicle (RAV) that collects data on the Canal including pH, oxygen levels, temperature, and salinity along with video and

photographs. The photographs are uploaded to a website, where visitors can tag them for environmental features (e.g. tree or bulkhead) or visual pollution. Another institution-led citizen-data collection initiative involves citizen reporting – sending video footage and/or photographs of events/incidents in the Canal to the EPA Superfund officers directly. While this is an informal activity, as I show in the next chapter, the authorities greatly value these contributions.

Grassroots-led initiatives include the Gowanus Dredgers, a group dedicated to environmental stewardship and education, water quality monitoring, and advocating for access to clean waterways. Another initiative is 'Enquete Gowanus', a Genespace[28] project conducting citizen-based DNA sampling of the Gowanus Canal's sediment microbiome. The Proteus Gowanus also had ongoing citizen-led interdisciplinary projects investigating the history, health, and possible solutions to the issues on the Canal. Other citizen-led initiatives have taken shape around specific issues other the years, for example, a problem persisting 2 years was finally addressed in March 2016 through a survey presented to the local authorities. On their blog (Figure 12.4) they present the results.

Another initiative is the 'Gowanus Low Altitude Mapping' (GLAM), which I followed for three years. The grassroots initiative began in 2011 as a response the issue of sewage overflows diverting rain water into the sewer system: "we've launched the Gowanus Low Altitude Mapping Program were we tie helium balloons and send them up a 1000 feet to take pictures of the Canals' water quality and opportunities for improving it" [presentation speech]. Their DIY methods/approaches include aerial mapping, NIR mapping, water quality testing, historical analysis, and environmental advocacy.

[28] A New York-based non-profit organisation dedicated to promoting Do-It-Yourself biology and access to biotechnology.

Worried about health concerns, a small group of residents organized earlier this year to bring awareness to these quality of life issues. Hoping to gather supporting data, the group circulated a survey entitled "Smith Street Stank, Dust And Noise."

The results of the survey are now complete. About 180 people took the time to respond to the various questions. The data seems to clearly show that smell, noise and dust are a problem on that end of Smith Street.

The results of the survey will be presented by local residents to Community Board 6

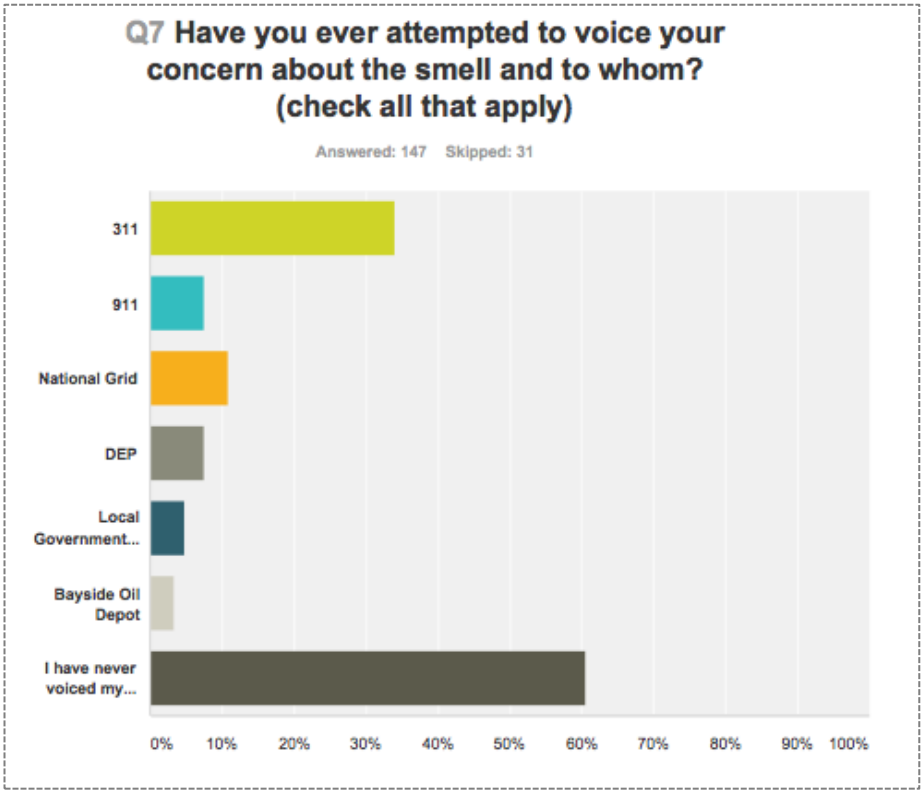


Figure 12.4: Sections from a blog post presenting the issue and survey results from citizen-led enquiry into local pollution.

Since then, with the lead of one individual supported by members of the public and other community organisations, the group has mapped several aspects of the canal and surrounding areas. One initiative was the project 'Over my dead body' in 2013 in which the group collaborated with historians and the NY police to explore the site of the Battle of Brooklyn in the War for American Independence in 27 August 1776 adjacent to the Canal. Their initial research questions included 'How much space would bodies take?' and 'Where could have bones survived?'

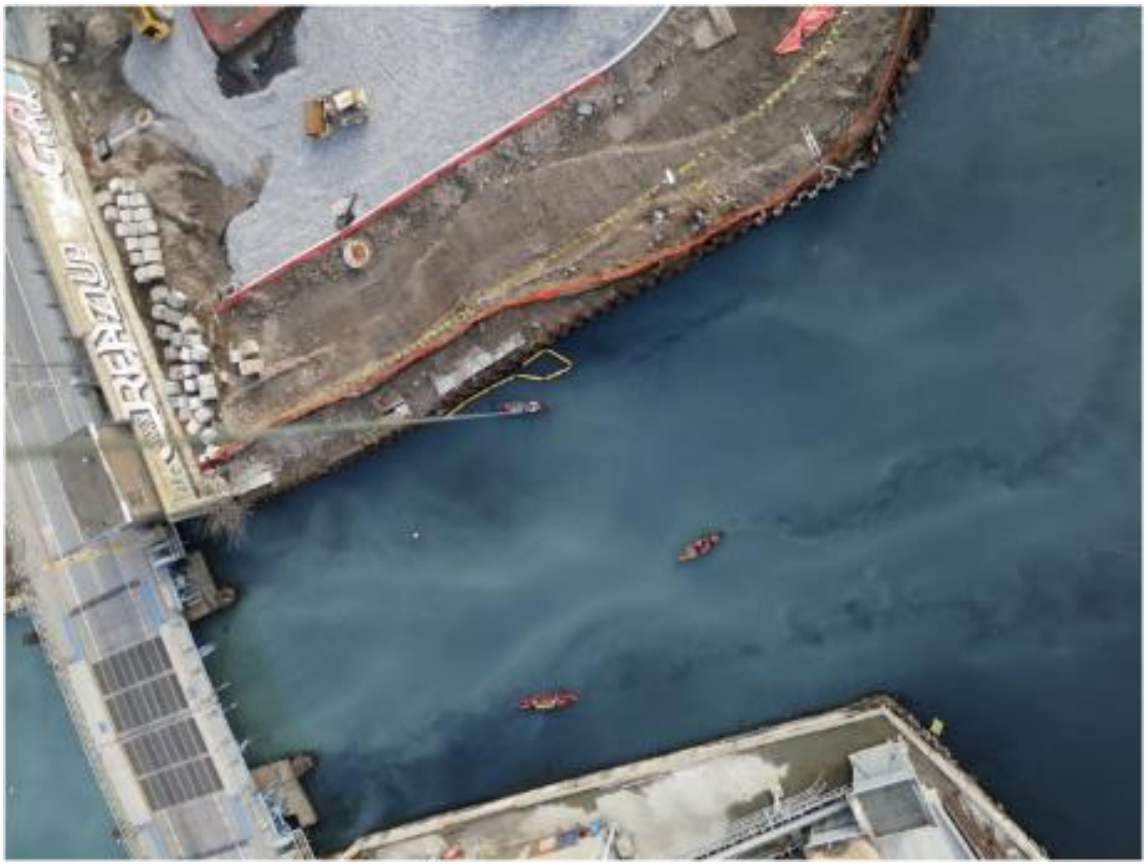


Figure 12.5: Gowanus Canal community mapping of sewage plumes from hurricane Sandy damage, 2012. The photo features three canoes, one of which is holding the line to the weather balloon with a camera attached – the line can be seen running from the centre to the left of the photograph. [Source: Public Laboratory]

Another initiative was the mapping of sewage plumes from the hurricane Sandy damage in 2012 (Figure 12.5). The project led to the ongoing 'Ghost stream mapping' project using a 'crime scene investigation' (CSI) method. With this project "...we are interested in spots were rainwater could be diverted out of the overloaded sewer system and into old historic stream beds that got buried a hundred years ago. The idea is that by figuring out a more natural and sustainable manner to manage our rain water we can be better prepared for the big disasters" presentation speech]. Figure 11.4 marks one of the 'turning points' of their enquiry: "This for example is balloon photo taken by our canoe team right after the Sandy Hurricane, which caused our local sewage pump station to explode, pouring massive amounts of sewage into New York waters" presentation speech].

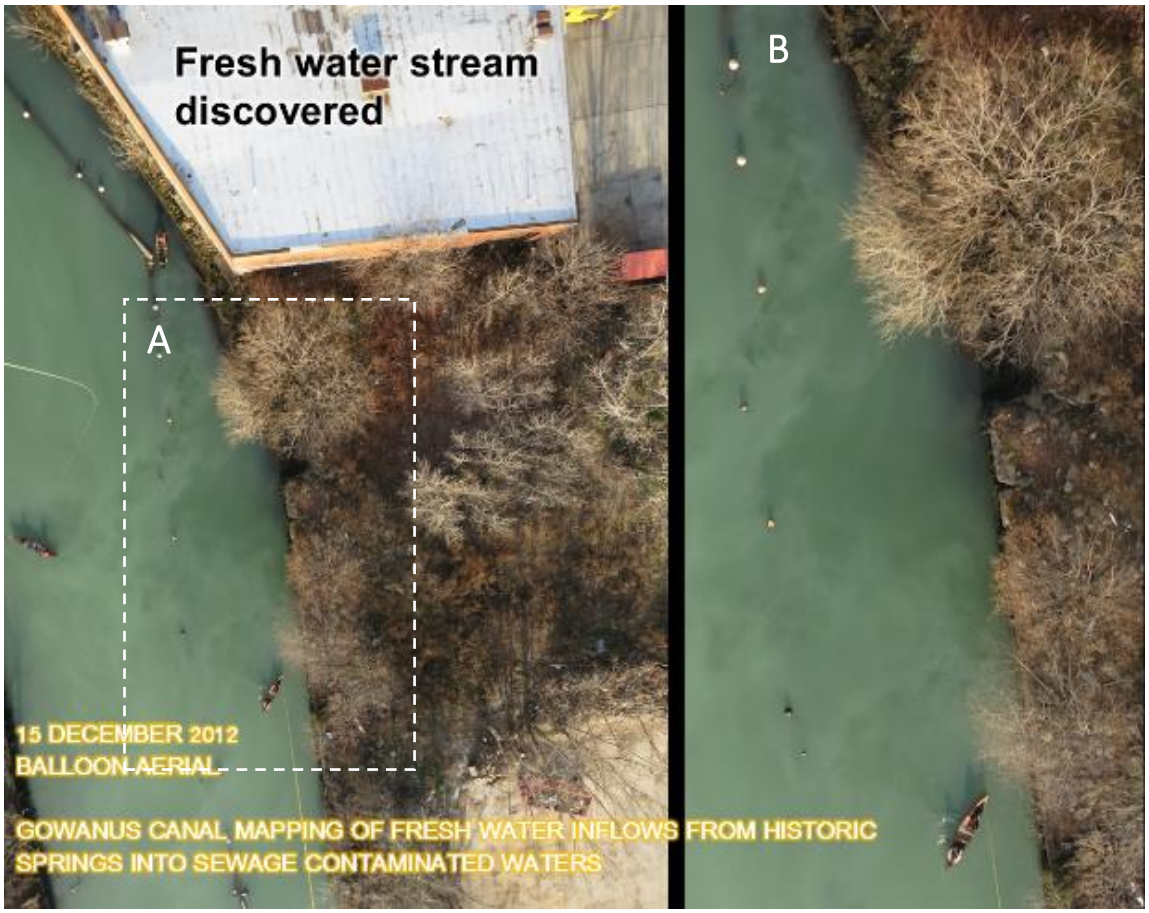


Figure 12.6: DIY aerial photographs showing 'milky sewage' plumes. A) Original aerial photograph; B) Close-up of interesting phenomenon spotted on original photograph – believed to be fresh water discharging into the Canal. Evidence such as this prompted the group to investigate further.

Members of the group are invited frequently to talk about their work at universities and community events. One of the questions they pose to their audiences is "but what can better quality Citizen aerials actually tell us?" Their argument for citizen data:

> Here is an example in this post Sandy photograph [Figure 12.6] – we notice that most of the Canal water is a milky sewage contaminated white – but look – there is a darker spot to the right of the photograph – what's that about? A historic spring is pouring fresh water into the Canal. […] How can we find out more? […] Can we map all the old ghost streams & creeks? These can help to divert rainwater out of sewers and reduce sewer overflow pollution [Presentation speech].

They explain that these lines of enquiry led to further enquiry and examination of other aerial photographs. The presentation speech continues:

> And this is a view taken from a balloon in the air [Figure 12.7A] – you will note an unusual streak of green weeds running across the cement paving grid. But when we

> look at historical maps of the area [Figure 12.7B], before it was filled with toxic waste, we notice in blue that we thought was quote unquote "land" was actually a massive pond with streams zig zagging all over the place. If you were in a time machine […] and we went back a century – you would all be swimming right now as "Flushing Meadows" was built on tidal marshes very similar to the one in this map. Which when we overlay the water layer from the 1766 map, we see a small stream next to an old mill building – early settlers would build their houses next to fresh water springs as Gowanus water was too salty to drink. So now we have found the source of the flowing water [Figure 12.8]. [Presentation speech]

In my third visit to the Canal I interviewed members the Gowanus Canal Conservancy, the Proteus Museum Gowanus, GLAM, and the EPA. At my last visit I had informal conversations with a member of Brooklyn Atalntis and observed the RVA's functions on the Canal. As participant observer I also accompanied members of Enquete Gowanus on one of their sediment sampling expeditions and informally talked with them about their project. GLAM was of particular interest as it has connections to all the above organisations and initiatives, providing an opportunity to study how DIY environmental enquiry unfolds in a real-world context.

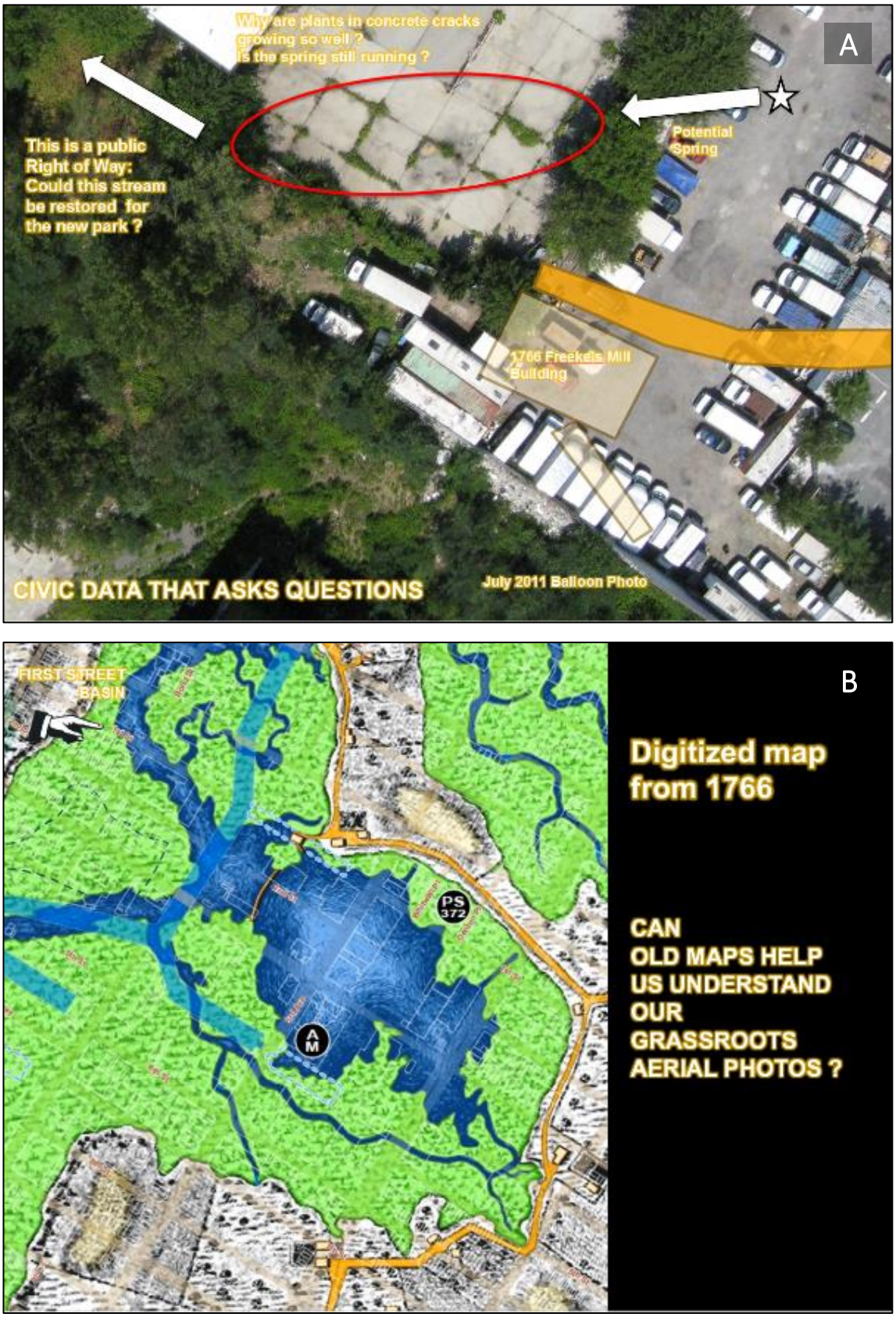


Figure 12.7 A) DIY aerial photo with annotation of hypothesis and historic features. B) Digitised map from 1766 overlaid by a city ordinance map.

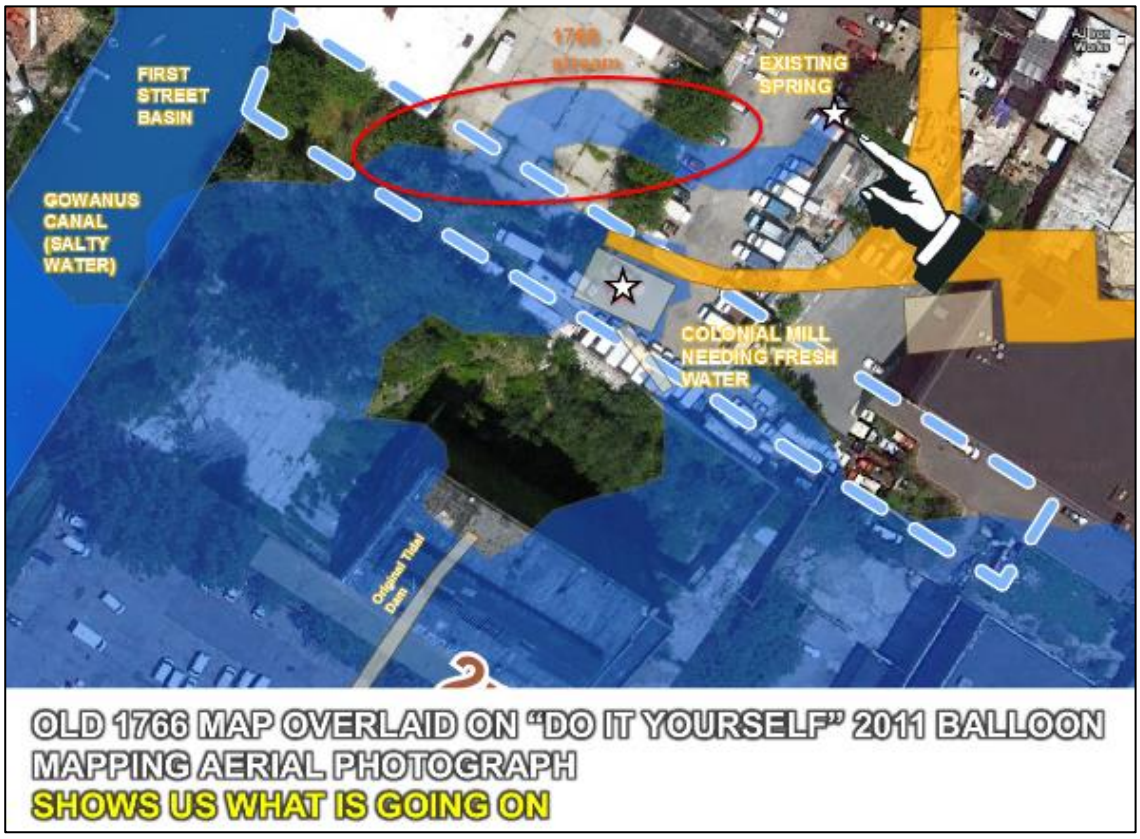


Figure 12.8: Digitised historic map overlaid on DIY aerial photograph annotated with findings from CSI investigation.

12.3 Methodological strategy: Place-based citizen initiatives of DIY enquiry

This case study enabled me to critically look at the concepts and model on DIY enquiry developed from the other case studies. This case study did not directly contribute to the development of the original theoretical framework, rather, it functioned as a way to 'test' its initial concepts. Preliminary analysis of the data collected from the first two site visits revealed 'granularity' as the main 'strength' of grassroots initiatives and 'persistence' their main attribute enabling production of knowledge and the leveraging of that knowledge to engage in action. Specifically, persistence by specific individuals, or 'community champions', over several years on environmental monitoring and public participation initiatives had had an impact on public and governmental perception and discourse. The extent of this impact

was not clear and the third visit revealed insights that deepened and refined the theoretical framework. The full analysis is presented in Chapter 13.

Selection rationale: This case study was selected because it contributes the perspective of initiatives of DIY enquiry in a real-world context – with all the richness of experiences and factors affecting engagement in DIY enquiry initiatives ranging from the development of techniques and strategies supporting investigative efforts to the politics of advocacy and leveraging of knowledge in interactions between different stakeholder groups.

Design frame: This case study is key as its contribution is crucial to understanding engagement in DIY enquiry in a real-world context. It also provides key insights into the processes of engagement in DIY enquiry at the individual level mediated and shaped by the societal context. The purpose of the case is also instrumental in that it contributes insights at the personal, organisational, and community levels that complement the understanding of the broader picture of DIY enquiry. It is also an exploratory case due to the nature of the research. As with the other case studies, the outcome(s) of the situation – in this case citizen-led environmental monitoring – is not known and processes are not clear. This case study helped to establish ways of understanding and framing DIY enquiry in the real-world context of citizen efforts. It provided themes and categories that point not only to the socio-technical but also to the socio-political aspects of DIY practices. As with the previous main case, all empirical data collected was used in the theory-building approach of Grounded Theory. This case is also part of multiple parallel case studies with elements of research interest nested across cases. The design frame is illustrated in Figure 12.9.

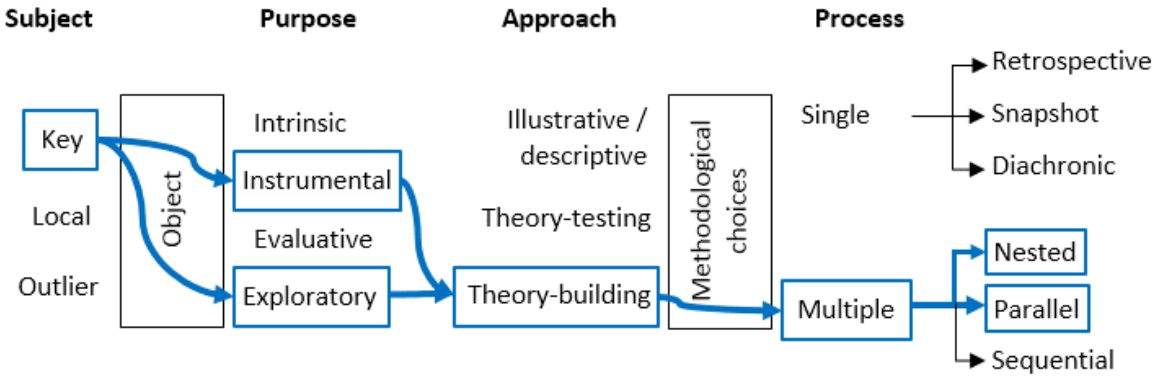


Figure 12.9: Research design for the place-based citizen initiatives of DIY enquiry case study.

Sources of evidence: Long-term direct immersion in this case study enabled me to collect many sources of evidence to analyse and triangulate findings. These are listed in Table 12.1.

Table 12.1: Sources of evidence for Place-based citizen-led initiatives of DIY enquiry

Data type	Description	Year
Documents	• Historic text 1906 BSc. MIT thesis on "Improvements of the Gowanus Canal" • Presentation historical background & data of pollution in the Gowanus Canal – citizen research • Comments on EPA Superfund Proposed Plan – citizen concerns • History of the Gowanus Canal for the Gowanus Proteus Museum – citizen research • News article on citizen inquiry & research claims & results • News article on the approach & methods based on community use of DIY aerial mapping in the Gowanus Canal • 'Research notes' on results from citizen investigations: Hurricane Sandy sewage overflow aftermath; 'ghost' stream mapping and research; mapping & research on potential burial site for American Revolution soldiers	1906 2012 2013 2013 2014 2014 2014
Audio recordings interviews	• 11 audio recordings of community meetings & conversations with local residents on environmental issues in the Gowanus Canal & initiatives to address them • 4 in-depth interviews with local residents & community group member about citizen initiatives of environmental monitoring	2014
Video interviews	• 5 short video interviews with local residents about significance of the Gowanus Canal, environmental issues, & knowledge of/participation in citizen initiatives	2014
Audio interviews	• 3 in-depth interviews with EPA and community organisation on citizen initiatives in DIY inquiry (*interview guide based on theoretical concepts and framework*) • 1 conversation about citizen initiatives in DIY inquiry with community member	2015
Audio recording	• Meeting by the Gowanus Canal Community Advisory Group on Archaeology	2015
Photos / video	• Gowanus Canal context & setting	2014-15
Field notes	• Observation notes and reflections on citizen initiatives at the Gowanus Canal: individual & societal factors influencing engagement; tools, approaches & strategies	2014-15

With this background on the study of DIY enquiry in the context of place, we move to the case study analysis, which offers a Grounded Theory explaining the phenomena in this community.

13. Place-based citizen initiatives of DIY enquiry: Case analysis

13.1 Comparative process and research dimensions

As with previous case studies, the scene for the analysis by presenting the initial and emerging guiding concepts of the case but unlike the previous cases, no preliminary model was developed, rather, the case served as a way to 'test' and refine concepts from the other case studies. The second section presents that theoretical sampling and the third moves onto the theoretical integration and Grounded Theory for DIY enquiry in the Gowanus. I end with a discussion comparing the concepts from previous case studies and present a revised conceptual model for DIY enquiry.

13.1.1 Guiding concepts, dimensions, and subdimensions

Initial concepts from previous case study directed the research questions towards citizen-led initiatives in public engagement in science and technology. Subsequent questions about 'DIY-in-context' began to emerge from observations from the Public Lab community case study and an extensive literature review. The *generative questions* about the roles of the institution, technologies, the setting, and other conditions hindering, maintaining, or promoting public engagement from these case studies were asked 'outdoors'. Thus, while the dimensions and subdimensions in this case study were initially defined by the other cases, the theoretical sampling – or refinement of theory – revealed the most salient aspects of DIY enquiry in practice in a place-based context. This also resulted in the emergence of missing links and tensions in the understanding of DIY enquiry in practice, thus bringing together a more nuanced understanding of DIY enquiry.

Table 13.1 lists the salient categories and subthemes used and generated through the coding process. A complete list and description of the 178 codes identified for this case study can be found in Appendix D.1.

While many of the categories and their subdimensions in this case were defined by and coincided with previous cases, some subdimensions, not surprisingly, did emerge directly from the data. For example, the actions *highlighting/identifying need*, *providing proof*, and *lobbying/advocacy* are salient and completely emergent themes – entirely grounded on the data. In Table 13.1 the 'Source' column includes 'cases', meaning that this dimension drew its origin from another case study.

Table 13.1: Themes and their subdimensions generated during open coding – Place-based citizen initiatives of DIY enquiry

Category	Subdimension	Grounded	Density	Source
Engagement	Condition for engagement	52	6	Coding paradigm
	Reason for engagement	39	11	Literature/cases
	Barriers to engagement	29	7	Literature/Cases
	Engagement process	28	15	Cases
	Consequences of engagement	27	4	Coding paradigm
Science	Environmental issues	71	21	Data
	Methods/activities	41	9	Cases
Knowledge	Local knowledge	37	13	Data / Literature
	Technical knowledge	35	11	Data / Literature
	Production of knowledge	35	16	Cases
	Enquiry	28	14	Cases
Context	Gowanus	75	21	Data
	Institution / government	56	18	Data / Cases
	Community organisation	49	21	Data / Cases
Interactions	with authorities	47	19	Data / Cases
	with the public	43	13	Data / Cases
	with artefacts	42	14	Data / Cases
	with the environment	24	6	Data / Cases
	with community groups	24	9	Data / Cases
Artefacts (symbolic & material)	Infrastructure	37	8	Data
	Data	35	21	Data / Cases
	Political agenda	20	2	Data
	Digital technologies	19	3	Data / Cases
DIY	Science efforts	37	18	Cases
	Methods	18	12	Cases
Strategy (Organisational)	Encouraging engagement	26	9	Coding paradigm/Data
	Working across barriers	23	9	Coding paradigm/Data

	Making use of circumstances	19	7	Coding paradigm/Data
Actions	DIY sensing	27	17	Cases
	Highlighting / identifying need	27	10	Data
	Providing proof	21	15	Data
	Lobbying / advocacy	18	10	Data
Responses	Aspiration	29	7	Cases / Data
	Importance	28	4	Cases / Data
	Disconnection / dissatisfaction	25	12	Cases / Data
Role	of Citizen efforts / community organisations	41	20	Data / Cases
Sharing	data / information	30	10	Cases
Perceived impact	n/a	26	8	Data / Cases

13.1.2 Theoretical sampling

The salient themes for citizen initiatives of DIY enquiry at the Gowanus Canal are:

- *Environmental issues* and its relation to salient categories of 'context', 'artefact', and 'action';
- *Production of knowledge*, *Enquiry*, and the *DIY method* and their interrelation to 'DIY citizen data', 'DIY science efforts', 'DIY sensing', 'interactions with the environment', 'exploration', and 'providing proof'; and
- *Lobbying/advocacy* in relation to *interactions* with *authorities*, *community groups*, and *artefacts*.

Sections 13.2 and 13.3 discuss the relationships between the most grounded and dense subthemes in Table 13.1.

13.2 Theoretical sampling: Environmental issues

With 71 occurrences in the data (Table 13.2) *environmental issues* emerges as the most salient theme linked to most code categories. Figure 13.1 illustrates insight into its main subdimensions. Not surprisingly, its highest co-occurrence is with the context of Gowanus. *Environmental issues* is also associated with the contexts *institution/government* and *community organisation* (two additional salient themes) and with the *role of citizen/community efforts*. The most

salient artefacts in the Gowanus are *infrastructure* and *pollution* and linked to this, the most predominant 'action' is *highlighting/identifying need*. I discuss these themes in turn.

Table 13.2: Categories and their subdimensions (or subthemes) linked to the salient theme *environmental issues*.

Salient theme (groundedness)	Category	Subdimension	Co-occurrence	Co-occurrence frequency
Environmental issues (71)	Context	Gowanus	71	0.46
		Institution/government	39	0.20
		Community organisation(s)	28	0.15
	Role	Role of Citizen/community efforts	27	0.16
	Artefacts	Infrastructure	37	0.23
		Pollution	26	0.25
		Data	26	0.18
	Action	Highlighting / identifying need	31	0.21
		Lobbying / advocacy	26	0.19
		Providing proof	16	0.12
	Knowledge	Local knowledge	28	0.22
		Technical knowledge	26	0.18
		Inquiry	19	0.12
	Engagement	Reasons for engagement	27	0.17
	Interactions	Interaction with authorities	28	0.16
		Interaction with artefacts	23	0.12
	Response	Unacceptable	17	0.14

13.2.1 Contexts: Gowanus, government, & community organisations

In this section I describe the three most salient contexts in which the other themes in this case study unfold: the *Gowanus Canal*, *institutions/government*, and *community organisations*.

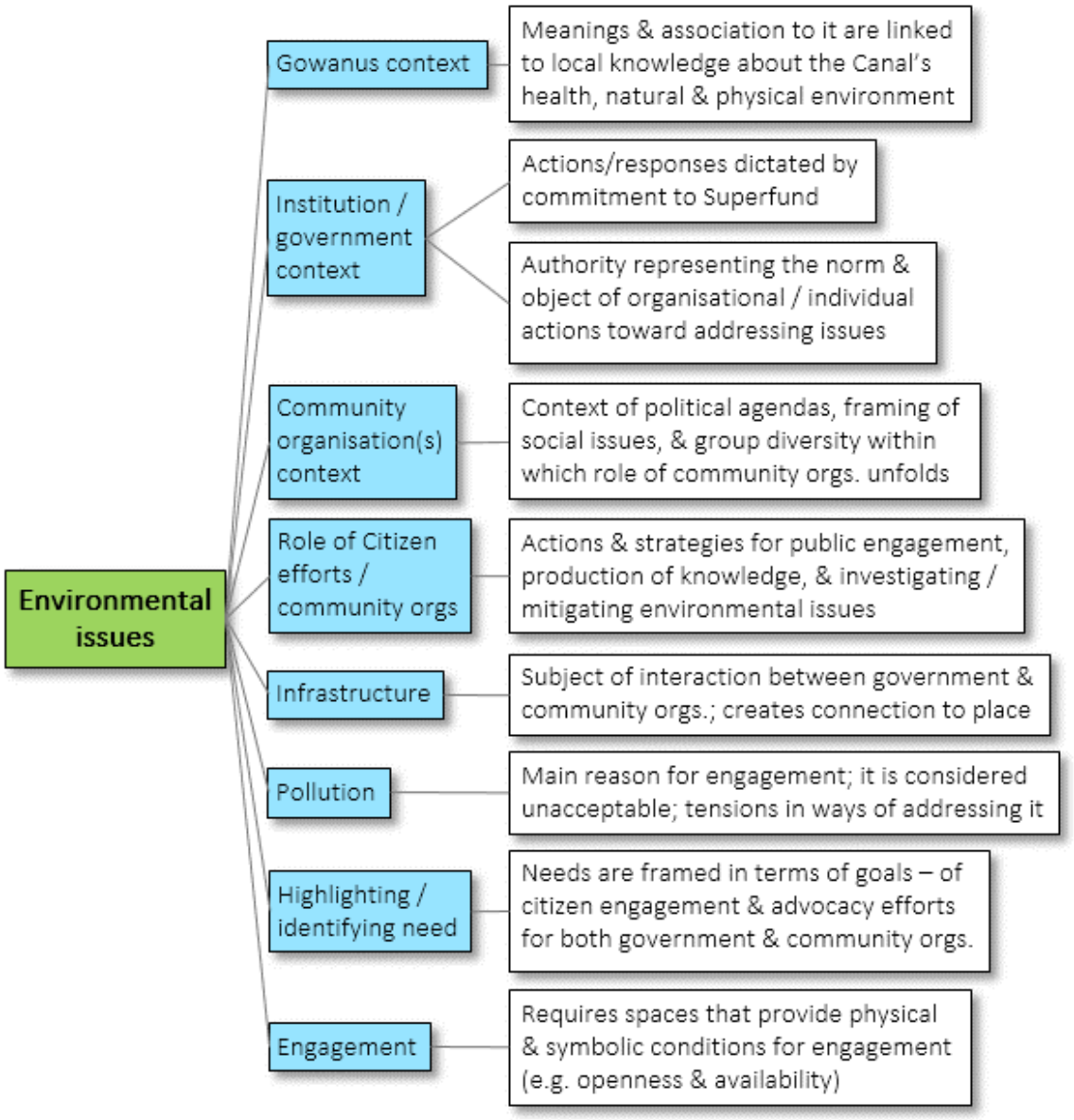


Figure 13.1 Theme map for 'environmental issues'.

The Gowanus Canal has "a certain fame" and "wide public recognition" [5:29]; its environmental condition creates interest, curiosity, and engagement. The nature of this interest/curiosity is expressed by local community organisers:

> … we get lots of people demographically 18 to 35 visiting from out of town, they want to see New York from the waterfront, and the grittiness is part of its appeal […] in a way it's a paradox for [European visitors] that the most powerful City in the world has really abysmal civil engineering […] [they] find it just fascinating [1:53; 1:56]

> …the Hall of the Gowanus just drew people from every discipline. Art, science, everybody. And there was a lot of interest in the Canal, you know, at that… once it became a Superfund site [6:186].

and an EPA agent:

> EPA apparently conducted studies where it was brought to the fore how contaminated the canal was, and that created curiosity […] So it's a huge, polluted site, right in the middle of a big urban environment, so that creates a curiosity, and I think it's a rich subject matter, in terms of contamination and effects of the contamination. […] [S]o it creates a curiosity by especially the academic groups, certainly by some locals who have a propensity for science, like [NAME], and so that creates the beginning of a project. [5:28; 5:265]

These portrayals/meanings frame the Canal's context of 'place', in which most other phenomena of DIY enquiry unfold. The *context* of *Gowanus* is itself strongly linked to the themes of *local knowledge*, *institutions/government*, *interaction with authorities*, *infrastructure*, *data*, and *enquiry* and the connections between 'place' and these salient themes in terms of *environmental issues* is evidenced throughout the sections below.

The context *institutions/government* refers to state agencies, in particular the EPA, and is directly framed by a commitment to the *Superfund* cleanup. This commitment shapes the agency's engineering activities as well as their public engagement strategies (and *interaction with the public*) and perception of *citizen data*, detailed in section 13.3.1 (p.300). The *institutions/government* theme is also strongly linked to *DIY science efforts* and *DIY tools* in their opinions/perceptions of them, as I show below.

The context *community organisations* encompasses the theme *role of community organisations/citizen efforts*, I therefore discuss them together next. Together these themes reveal insights into pushing *political agendas*, managing *group diversity*, the role/value of having space/place, and a sense of *connection* framed by perceived *social issues*.

13.2.2 Role: role of community organisations/citizen efforts

The salient theme *role of community organisations/citizen efforts* reveals the various *organisational strategies* that these groups develop, the nature of their *interaction with the public*, and the *aspirations* of community organisers. With NGOs' main goals of *raising awareness* and *promoting participation*, this theme also sheds light on *conditions*- and *reasons for engagement*.

The *role of community organisations* is characterised by a commitment to *raising awareness* and to *educate* mostly through *interactions with the public*:

> Well that's exactly why [we] are here […] precisely to provide a realistic forum for debate for a lot of those distorted horror stories that people hear about their physical environment. [1:223]

Expressed aspirationally, organisations also seek ways to improve on their role through "hands-on" engagement to "connect, the things that they do every day to this thing that's happening downhill" [7:27].

State organisations also express similar goals, as an agent recalls:

> EPA has encouraged a number of citizen projects at the canal over the past 5 years or so. Our main goal has been promoting public awareness and interaction. A secondary goal is the possibility that some interesting data would be produced. [3:2]

Community organisations also aim at creating dedicated spaces for engagement:

> …we decided to take these artefacts about the Gowanus, and turn it into a little museum, so we called it the Hall of the Gowanus. And we dedicated a room to it, so we had art, artefacts and books, all related to the Gowanus Canal, and so that grew, and it was very much curated by local people who live in the neighbourhood. [6:32]

At this particular community organisation *artwork* functioned as a medium to interact with the environment, engage in (critical) enquiry, 'raise awareness', shape identity, express and reinforce a sense of 'connection' with place, where people feel they can make a contribution.

Community organisations also serve the role of mediators between the public and the state/government: to "reconnect some of these lost pathways for data dissemination" [1:127] and "bringing community groups together and creating a plan, which is very difficult with hundreds of people who are interested and have a stake in the Gowanus, so helping facilitate that process is probably one of our biggest challenges" [7:74].

The analysis reveals that these collaborative goals of 'bringing community groups together and creating a plan' are represented through interviewees' own personal goals/agendas. These personal goals/agendas are themselves embedded in the politics surrounding the Gowanus Canal cleanup. It is also the political arena within which the *strategies* of *community organisations/citizen efforts* develop and unfold.

Specifically, these *strategies* take on two salient forms:

- *Organisational strategy* focused on *encouraging engagement* and
- *Personal strategy*, *working with/in the name of others*.

This disambiguation of 'strategies' gives nuance to De Certeau's (in Feenberg, 2003) 'tactical standpoint' because the analysis reveals a deeper interplay between *organisational* and *personal* strategies as interviewees reveal their own personal *political agenda*. Development of organisational and personal strategies involves: assessment of other stakeholders, personal and group interests, and opportunities perceived e.g. identifying common goals that bridge differences between different groups. A community organiser comments:

> [W]e were discussing establishing common goals between community groups that may not necessarily have had common goals, and identifying the common ground issues and the one everyone agrees on is better water quality [...] As a result, we've started throwing around discussions about, "Oh, what can we do about it?" [...] So that's another example of something that people are starting to agree on […] "alright, we need to really think about these strategic measures" [1:93].

This quote speaks to the perceived strategies developed to bring community organisations together (*working with others*) to agree on (*consensus*) and try to remediate environmental issues in the Gowanus. It also speaks to what is perceived as needed to get there and the intent of the interviewee in moving towards a 'common goal'.

Analysis of *political agendas* also reveals the interplay between *organisational* and *personal* contexts; agendas are conceived of and driven forward by individuals who give them validity by strategically presenting them *in the name of other organisations*. The interchange between 1st person singular and 1st person plural throughout the interviews (and exemplified in quote 1:259 below) speaks to this. Linked to the infrastructural/housing *development* around the Canal and the *Superfund* cleanup, *political agendas* of citizen/community efforts also become evident when interviewees highlight the tension that arises from the *diversity* of stakeholder interests/stances, especially when the agenda is ostensive:

> I have a particular political agenda which is that for us to get vested interests into the clean-up of the canal we need people living here again. Other people are opposed to that point of view and it's a perfectly valid point of view, but we are clearly stating this is our agenda and we're not doing it any dissimulated way [...] our stated mission is

> increasing public access by any means necessary to the waterfront and as such we have been supportive of that development. [1:259; 1:260]

As I show later on, the ability of individuals and groups to develop strategies to address the situation is a function of their continued engagement and their *reasons for engagement* but it is also mediated by their ability/willingness to leverage their accumulated knowledge.

In this analysis *political agendas* are symbolic *artefacts* and they are framed and used strategically by individuals and groups to achieve their goals. Additional artefacts in this case study play a role in steering citizen/community and state strategies while also being symbolically framed and reframed in the process. I discuss these next.

13.2.3 Artefacts: Infrastructure, pollution, & data

As both symbolic and physical artefacts, *infrastructure*, *pollution*, and *data* are the most salient themes in the context of the Gowanus Canal and *environmental issues*.

Infrastructure refers to the physical structures in the Canal such as combined sewer overflows, sewage storage tanks, flushing pumps, bulk heads, etc. However, symbolically, it also represents the technical failure and *unacceptable* state of the Canal's built environment (as portrayed in Figure 13.2). At the same time there are responses toward reflecting *ownership* over issue, courage and political will of taking ownership, and *connection* to place: "and we will make whatever political moves necessary to get to those goals" [1:336].

On June 21st 2011 local residents organised the 'Gowanus Canal Flushing Tunnel Centennial'. To tell the story of and "celebrate a giant plumbing device", "white lilies, symbols of purity, were thrown into the murky waters of the waterway with the hope that soon, the canal would be cleaner". It was also a way to "demand that the City stop using the canal as an open sewer" [11:4].

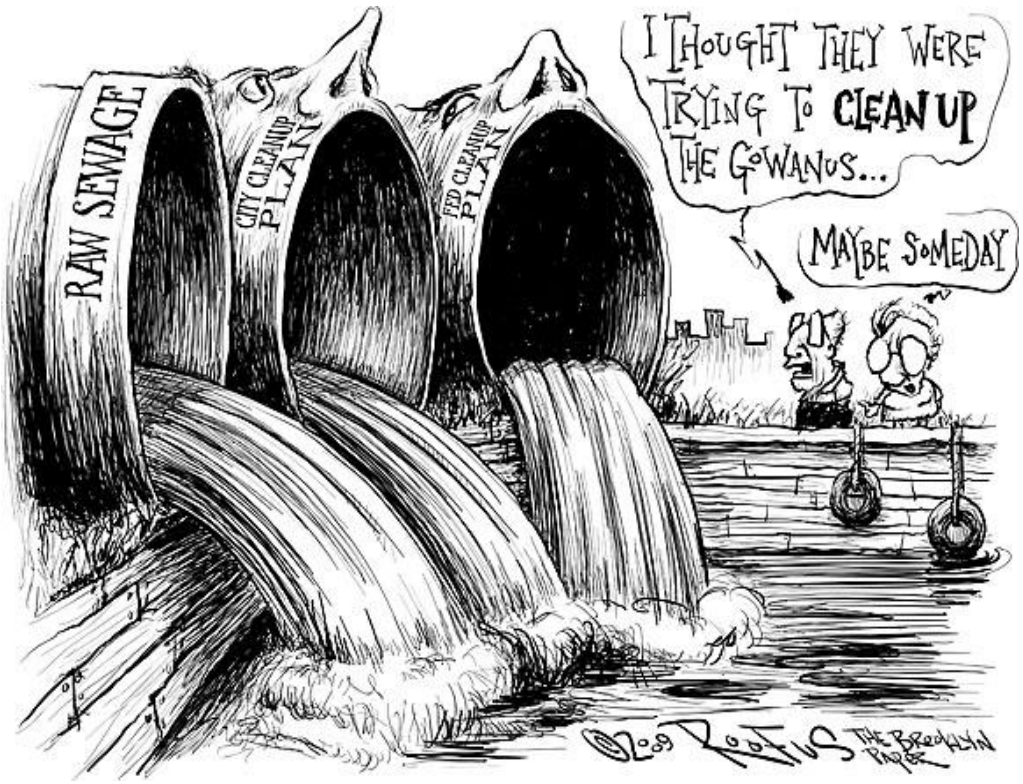


Figure 13.2: Symbolic and material representation of the Canal's infrastructure, environmental issues, those perceived as responsible, and attitude toward the situation. [Permission: Christian Fleming (Roofus)].

Pollution, not surprisingly, evokes a strong response of being *unacceptable*. As an *environmental issue*, it is the main *reason for engagement* and it is revealed through *story-telling* (as with the centennial celebration), *personal anecdotes*, and stories about the Canal. An organiser recounts:

> …when I came here I discovered, hey, there's a canal in Brooklyn and why not do something with it? Well, I soon discovered that it was incredibly contaminated [...] And I said, well let's get involved. It turned out that somebody already was involved. They were involved because in 1969 a flushing pump broke and they've been trying to fix it for almost 30 years, and so at that time I said, well let me get me involved, let me see what I can do, let's try to get that pump fixed. [1b:62]

> …what sells and gets people to vote and pressure is floating dog carcasses and comics* which have very little to do with the actual water quality but it's the visual [...] it gets them riled up [1:8] *See Figure 13.3.

Thus, it was revealed that community organisations and citizen efforts benefit from the pollution to meet their goals. But not surprisingly, too much pollution also curbs engagement.

The greatest tension around *pollution* is the *mismatch* between community and state focus in addressing it; community organisations target the pathogenic sources, whereas the EPA focuses on chemical/sediment sources and the DEP on infrastructure. An EPA officer expresses: "so the data that they will collect, it will not really inform the work that we do, because what we are cleaning is actually the sediment" [5:41]. Another tension stems from the measurements of the pollution. That is, between *citizen data*, and the state's positon on that data. This positioning ranges from *dismissal* to *strategic* consideration and is discussed in section 13.3 (p.299).

Figure 13.3: Popular/fictitious representation of the Canal's environmental issues. [Permission: Dave Kelly]

13.2.4 Actions: Identifying needs

The main challenge faced by community and state organisations in addressing environmental issues is gaining 'citizen engagement'. The specific *needs* identified to address this challenge are linked to *designing/planning* efforts and *lobbying/advocacy*. The analysis revealed that planning

and lobbying require *identification/recognition of issues* coupled with investigative/science activities, strategic leveraging of knowledge and stances, and long-term commitment.

Specific needs in 'citizen engagement' identified by community organisations include finding ways to outreach to underserved groups: "I think those communities have a lot to offer. Not just because I wanted to give them what we had to offer, but I think that they could have offered [...] a very rich, different viewpoint" [6:157]. There is also a need for funding but also research into better methods to address pollution (e.g. *designing/planning* DIY green infrastructure and development of targeted DIY tools such as a do-it-yourself oxygen meters). On the other hand, needs for 'citizen engagement' identified by state authorities are linked in part to "the possibility that some interesting data would be produced" (see [3:2], p.292) as well as the potential pressure that the 'symbolism' of citizen data could produce; referring to how Riverkeeper data could be useful, an EPA agent comments:

> Certainly at this point it would be nice to get real-time data that shows that… City's technical assessment of the cleanliness of the canal for clean water purposes, pathogens, and dissolved oxygen in particular – *that* would be a great thing not because it directly affects our work but because it directly supports the need for our work. [4:18]

In this case, the EPA's interest is in pressuring the City (the DEP) and questioning its monitoring methods. It is perceived that citizen data can complement the EPA's work. The interviewee continues:

> So last Friday we had a debate with the City about rainfall – here is another citizen-data opportunity – frankly, the City relies on National Weather rainfall meter as part of the input to their model to determine how much *estimated* – not *actual* – sewage overflow there is. … I and many other people have mentioned this as a concern to us over the years... [4:33]

The value of citizen data (as a symbolic artefact) is framed by needs and goals and this is directly linked to strategic leveraging of knowledge, which I discuss in section 13.3.1 (p.300).

13.2.5 Engagement

Engagement in the Gowanus occurs mainly within the context of *community organisations* and *institutions* as these provide the conditions (which are in turn *consequences*) for engagement: promoting *interest*, *curiosity*, and *learning* (gaining new skills, verifying knowledge, etc.); creating

new *meanings* and *connections* (to place, environment, authorities, etc.); finding outlets to voice ideas/concerns (creative expression, fora with authorities, etc.); and therefore opportunities for people to feel that they can "talk about real issues and feel valued and like we have an impact on our environment" [2:297]. A specific condition for this engagement is physical and symbolic 'space':

> [I]t was a place to come, warm, and you can show your work, and that was a big deal … we called it sort of knowledge-seeking, or… it was just sort of a place where you could explore topics, so anybody who came in could engage with it. And I think that was very empowering for the community [6:207]

To address the lack of "connection to the history, the community, the environment" the above organisation identifies that what is needed is "just engaging people in creative conversations, that lead to projects, and make people feel like they have an impact on their environment, and the world" [6:119].

Physical and symbolic 'spaces' for engagement are also perceived as *valuable* by both community and state organisations. As a space to promote understanding and acceptance of state plans, the EPA describes the CAG as

> a venue for us to go and explain our work, on a regular basis, and then it makes it easier for us to do our work, because there's less opposition; you oppose something when you don't understand it well. If you have understood it, and if you agree with it, then you're not going to oppose. So we do derive a benefit from having that group. [5:84]

And a community organiser expresses about the EPA's use of its organisation's space:

> [W]e had various people coming through who were working for the EPA, and they found it interesting, too –as a community base. [6:124]

Finally, according to a community organiser, those who engage with environmental issues in the Canal are young people who have not yet settled "into the neighbourhood" and who "want to transform their environment […] and therefore have a vested interest in making what is still a gritty rough neighbourhood into something that's liveable and also connecting with other people who want to do so" but also who "have the time and motivation to do so" [1:199], pointing to a perspective on reasons for engagement.

13.3 Theoretical sampling: Knowledge production, enquiry, and the DIY method

The three salient and interrelated themes *knowledge production*, *enquiry*, and *DIY method* constitute the *process of engagement* in DIY in the Gowanus (Table 13.3). Their salient subdimensions discussed here are *citizen data*, the *science efforts* associated with it, *DIY tools*, *DIY sensing*, and *providing proof*. Figure 13.4 maps the insights gained from analysis of these salient codes.

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Table 13.3: Categories and their subdimensions (or subthemes) linked to the interrelated salient themes *production of knowledge*, *enquiry*, and *DIY method*.

Salient theme (groundedness)	Category	Subdimension	Co-occurrence	Co-occurrence frequency
Knowledge production (35)	Engagement	Engagement process	23	0.29
		Learning	11	0.17
	Knowledge	Creation of meaning	11	0.21
		Inquiry	13	0.25
		Local	16	0.17
	Artefact	Data	17	0.18
		Digital technologies	10	0.12
	Context	Gowanus	28	0.18
		Personal anecdote	11	0.14
	Role	of technologies	9	0.17
Inquiry (33)	Engagement	Engagement process	20	0.24
	Context	Gowanus	34	0.23
	Interaction	with the environment	18	0.21
	DIY	DIY method	14	0.18
	Knowledge	Production of	13	0.17
		Creation of meaning	8	0.16
	Action	Providing proof	13	0.16
DIY method (25)	Action	DIY sensing	15	0.22
		Discovery	7	0.18
	Interactions	with the environment	12	0.20
		with artefacts	16	0.17
	Context	Gowanus	27	0.19
	Knowledge	Inquiry	14	0.18
	Science	methods/activities	12	0.15
	Engagement	Engagement process	11	0.13

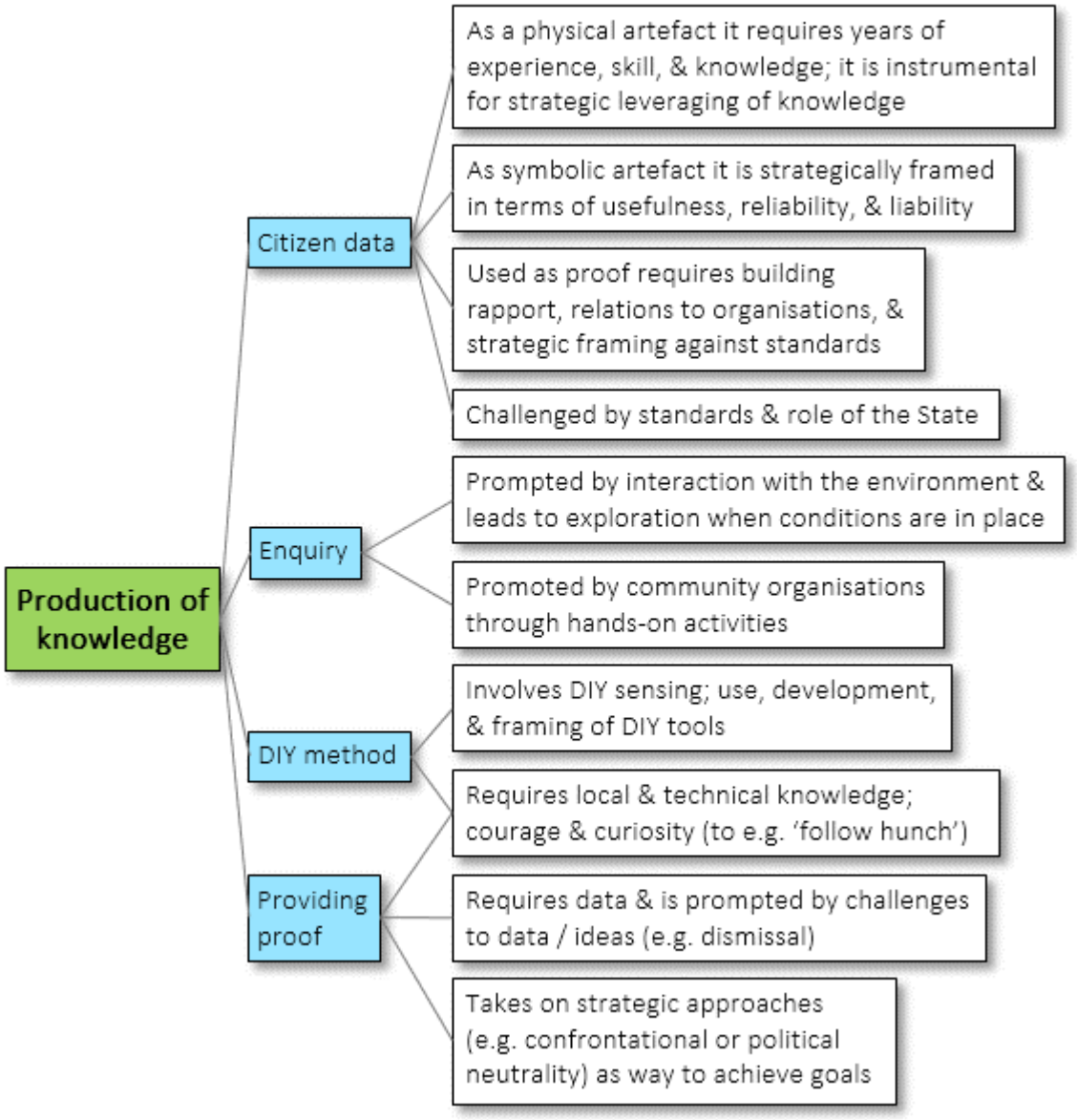

Figure 13.4 Theme map for 'Production of knowledge'.

13.3.1 DIY: Citizen data and science efforts

Data plays a role as both a *physical* and a *symbolic artefact*. It requires technical skills, knowledge, and tools to obtain it while also needing strategies to frame it and leverage it. Thus, the challenges and opportunities that arise from these nuanced affects shape the way DIY science efforts unfold.

As a *physical artefact*, citizen data requires technical skills for collecting and interpreting it. DIYers in this case study gained these skills through self-learning, trial and error, and experimenting:

> …it's, looking for unusual patterns and just going on random hunches- it's like, go for a random belief and then try to test it with the evidence and then it'll fail 80% of the time, but after a while your hunches become even more on target. So, the idea is to think- I don't know whether they call it thinking outside of the box- but to not be scared to come up with crazy magical ideas, right? And then prove that the magical idea is not that magical, it's actually very fact based. [2:196]

Skills to gather data and interpret it also require years of experience and previous knowledge. Experiences from both an EPA agent and a local organiser (respectively) concur on the value of observation and tacit knowledge:

> I was curious to know how the sheen… [see Figure 12.5, p.278] it was not intuitive to me where the sheen were coming from. I mean, I would think –the intuitive part– would be that oil comes somewhere from the side, slips in and then becomes a sheen. And so I spent days on the top of the Canal, I would go frequently [...] and on one or two occasions I was able to see the mechanism of the creation of a sheen. I could see to almost the bottom of the Canal, or very near it, and I would see gas bubbles that were created by the actions- because you have different chemicals coming in, so you have biological activity, and you also have chemical interaction, so the by-products of the actions is gas. [...] And when it comes to the top, it creates … that little sphere becomes a stain the size of a quarter, an American quarter, and then it spreads to many square metres in area of different colours, because their surface tension changes at the top… well, that was a lot of information which for me, was about the mechanism of the creation of the sheens and was based on observation. [5:153]

> …we could try to analyse chemicals in the water being, floating oil sheens, using cheaper do-it-yourself spectral meters that can differentiate between this or that oil pollution. But again a lot of that can also be done visually because after several years of experience canoeing around the canal, I can spot visually what kind of oil comes from where. [1:194]

The process of production of knowledge described here concurs with literature on prior and tacit knowledge (e.g. Rumelhart's (1981, in Glaser, 1984) 'schema', section 2.2.1, p.36)

Building and/or using tools for collection and analysis is part of these skills but a less obvious skill is that of how to strategically frame and therefore leverage the data, tools, and methods used to gain validity and present them as 'reliable' *proof* (section 13.3.3, p.308).

Figure 13.5: Sheen from coal tar in the waters of the Gowanus Canal shimmering in the sunshine. [Credit: HoleintheClouds.net]

This 'framing' brings us to data as a *symbolic artefact*. The symbolism represents the 'potential' of *citizen data* – of enterococcus measurements, aerial imagery, or sheen observations – to achieve some goal or *political agenda* (13.2.2). Analysis revealed that individuals and organisations strategically frame the 'potential' and therefore the value of data in terms of needs, interests, and standards.

Many of the examples of *citizen data* encountered in this case study were collected for a specific purpose, mainly, to provide 'supporting evidence' so "that meaningful action can come out of that" [1:380] as I show in section 13.3.3 (p.308). In this way, *citizen data* functions as a medium to negotiate interests between the state and community organisations, and strategies to leverage it are developed accordingly. For example, c*itizen data* is strategically used to build *rapport*, especially at the individual level: "it's a building up a rapport, and asking, not so much presenting the data as fact, but as presenting the data as questions for [authorities] to verify themselves" [2:114]. *Citizen data* is also leveraged to build 'relations' (alliances) and 'credibility' by establishing a 'common ground'. However, the time scales for these strategies vary significantly – from one-off stances to years of *persistence*:

> I've spent two years emailing every frigging official in the sun and trying to get these maps out there and showing them the aerials and it's percolating through, it's becoming mainstream, and I can guarantee four years ago no one gave a shit. Right? It wasn't even an issue [2:242].

Individuals and organisations also use *standards* strategically as 'frames of reference' to represent *citizen data* as 'comparable', 'granular', and 'useful':

> …the main tool that we use are the lab tools that are conventional for the EPA; we just collect the water and at this point it goes through a lab and an incubator and then is tested with light to look at the colony forming units, so we just use a standard practice [...] Because we're trying to precisely match the methodologies of the state, we use the same laboratory techniques as they do. And just so we can say that it's equivalent [1:193].

This quote speaks to the strategic use of *standards*; 'matching state standards' to make *citizen data* comparable is a way to find a 'common ground' by employing a common language of standards. This is akin to Carlile (2004) three-level knowledge boundary model (section 2.6, p.48). In some instances "it's pinned up there, I have the city data side by side with the citizens' data" [1:381] (Figure 13.6). *Citizen data* is also presented as providing *granularity* to the state's data. This 'comparative matching' is perceived as a way to pursue community goals and pressure the state on *environmental issues*:

> [We] decided to initiate a testing programme that was not meant to compete with the state data but rather to enhance it by providing more specific data that was customised to the groups' activities […] and put an end to the much finer scale- we were able to find out variations that had been missed by the state data. [1:106]

Conversely, *standards* are used to subject *citizen data* (and the effort associated with it) to specifications of validity, liability, and reliability. This brings us to the way the state assesses *citizen data*: 1) against its usefulness to completing the Superfund cleanup (as seen in 13.2.1); 2) the pressure it can put on the City (as seen in [4:18] and [4:33] (p.297)); and 3) its viability in terms of the expertise of those who collect it.

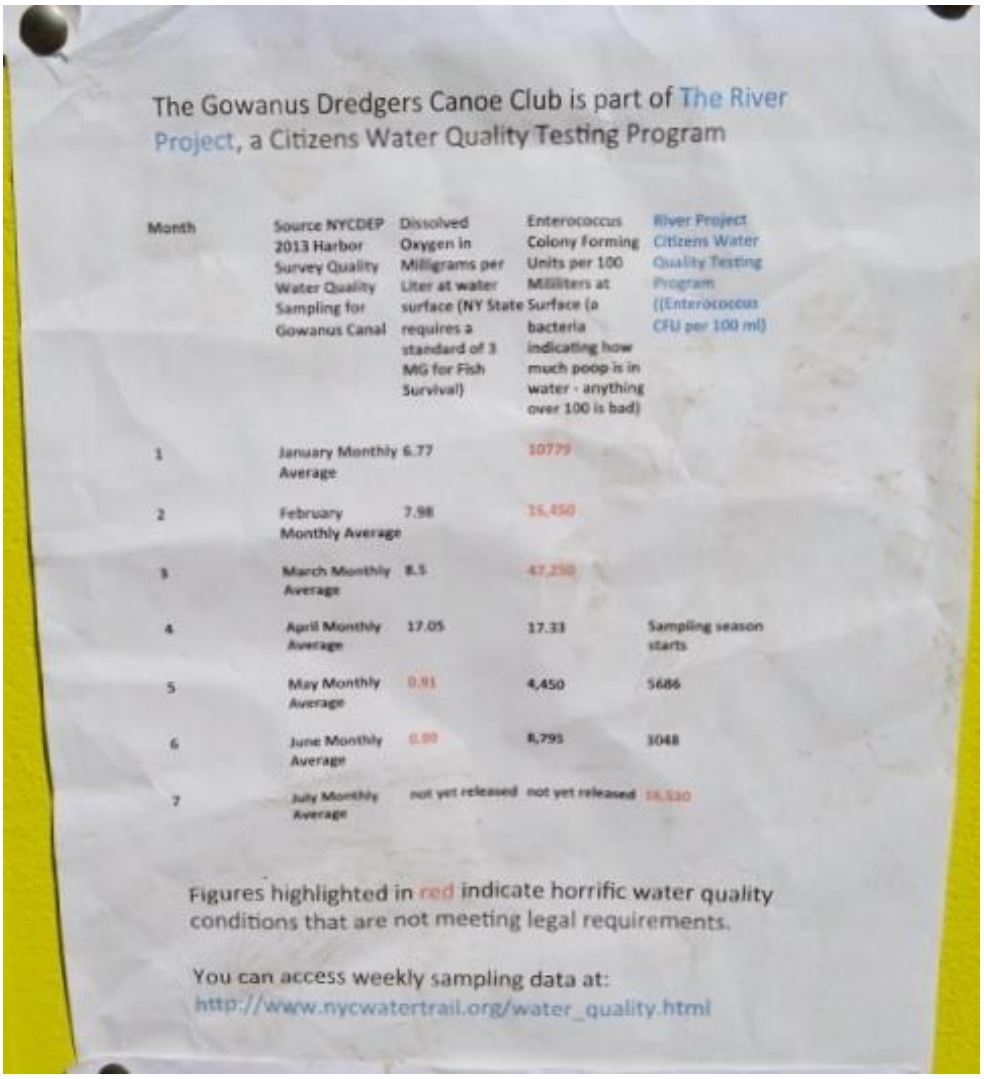

Figure 13.6: Results from citizen data-collection on pathogen levels side-by-side with State data placed at the registration table of a canoeing event at the Canal [Credit: Cindy Regalado].

Citizen 'contributions', imagery in particular, are valued by the EPA as useful qualitative input when linked to the Superfund cleanup "because we are not there every day. […] So we have that record, we had that visual record, which was provided by a citizen who was there […] [these] have been very valuable. And I encourage it" [5:161]. Here the state acts as the 'interpreter' of the *citizen data* and retains control over the interpretative process. On the other hand, data that has not been interpreted by the authorities or that does not coincide with a specific Superfund cleanup stage is treated with both 'curiosity' and 'caution'. An EPA official comments:

> I consider it unlikely that we will be considering citizen data as part of our current cleanup stage, which is the engineering design. This said, we have frequently considered

> citizen data and input on a qualitative level, particularly the type of mapping and studies done by [NAME]. [3:21]

Another official adds:

> For example, mapping of freshwater streams- of underground water streams […] it's a curiosity, that is of interest, it's good to know everything that happens in there, and … we keep that in the back of our minds, just in case in a particular location when we go and we excavate […]. So [NAME] has repeatedly brought it to our attention that […] there were some springs in that location. So it's […] different information than the one that we look for, but that might be of use… [5:260]

While it is acknowledged that citizen data fills a gap in the agency's knowledge, the main concern with *citizen data* is raised in terms of liability and reliability and it is framed in terms of *lack of expertise*, a position critiqued by Wynne (2009) (section 2.5.1, p.46). An officer contrasts traditional and DIY methods:

> Now, when you go do data-collection, there are issues that start first of all with liability, [...] in order to collect data from the canal, you have to put there a barge there with heavy equipment. Those who provide the barges – those who provide the equipment – have to have insurance, and so in order to have the insurance, there are certain provisions in there as to the expertise of the [...] people who are going to be there, and who will be using that equipment [...] and that provides a limitation. [...] The other issue is of expertise. So, yes, they're going to collect the data, but are they qualified to interpret the data? And… because you can make… and there are mistakes being made. So if you do not know the subject well, and you make the wrong interpretations and the wrong projections, it is not a good situation [...] because there is the potential of creating misinformation, which can create panic in cases as a Superfund. So that is the other limitation. […] we always rely on peer review, and repetition, reproducing results, and that's … so we are trained to do that. If that becomes part of establishing a culture within citizens at a certain site, then I would say, OK, […] but one has to be always aware of the dangers. [5:179; 5:184; 5:198]

In this case official *standards* and procedures dictate the response from the state. The quote also highlights the interconnected procedures that support and perpetuate the 'official method' (e.g. licence for insurance). It also reveals the value placed on professional expertise against which citizen efforts are measured.

At the same time, these responses shape the way DIY science efforts unfold. For example, an interviewee shares that they "welcome" being *confronted* and *challenged* by the authorities: "because I'm challenged on the science I actually get better knowledge and from that we get policy actions" [2:326]. The process of being *confronted* and *challenged* through interactions with authorities (and in some cases reporters and other researchers) sets in motion a process of learning (*production of knowledge*) and developing *strategies* to move DIY enquiry forward. However, 'reshuffling' of ideas and strategies in DIY is not seen as an easy process:

> …these are actually complicated painful issues. Some of these things are going to require a lot of thinking because you do one thing, it'll solve that, but it will cause another problem […] So, recognising that is a great thing [...] we need to look- use the data to precisely raise the dilemmas [1:173; 1:177]

This example highlights that an ability and willingness to accept critiques as challenges and to seek new knowledge to support or disprove ideas is an important part of the DIY enquiry process.

It is important to note that for some community members the purpose is not to redefine 'science' but rather to integrate 'science' as part of the *DIY method*, which extends beyond the bounds of 'science': it "sets up a process of challenge and counterchallenge which is positive and that's precisely what we call the scientific method […] science is the process of enquiry by which facts are acquired to understand how the world works but not necessarily to change- that's not a given as part of science" [2:2; 2:91]. It also clear that the main motivator for these efforts are "so that it can give us guidance for particular policy actions […] data's meaningless unless it leads to some sort of action or policy recommendation or change [1:138]. Here the politics of DIY enquiry is highlighted and it is clearly a means to an end.

While the state's responses to DIY initiatives have shaped its strategies, DIY efforts have not had the same effect on State authorities' strategies, as I show in 13.3.3 quote 4:75.

13.3.2 Enquiry and the DIY method

The analysis reveals that *enquiry* and connection to 'place' are fundamental conditions for engagement in DIY environmental monitoring.

> And from what was just an accidental like- you pick up the book and then you open up the story and to do that you have to peel away stuff and look for the little clue, whether it's this strand of hair or the trickle of water, or you know, the scratch in the dirt, the footprint. The clue. And a lot of science, do-it-yourself science, is about looking for clues and then imagining the story and sometimes it's fantastic and it's just fable, and other times it's real. So for me what started off as a fable was now actually damn serious [...] So that's a challenge for do-it-yourself science, should it just be the power of belief or should it be the power of fact that is unrevealed- that you have discovered or was unnoticed, a smaller fact, the dust that no one thought was relevant- and then you bring it forward and say this is a story that actually has a real narrative and a real implication for *now* [2:48; 2:51].

This quote speaks to the nature of enquiry and the DIY method: its spontaneity, what it takes into consideration, and what it enables and values. DIY *enquiry* in the Gowanus is mostly linked to *interaction with the environment* and *exploration*. The DIY approach to enquiry is driven by *curiosity* and requires *taking initiative*:

> Wandering along the presumed course of 'Vechte's Brook', [they] repeatedly dropped to the ground to listen at manhole covers and drains. [They] blurted out contextual clues- that anomalously large tree hinted at a steady water source- a discharge pipe protruding from a school basement spoke to regular flooding… "That's as good as a chalk outline on a sidewalk," [they] said [8:6].
>
> Last month, [they were] walking through the neighbourhood […] Armed with an old map of the Gowanus estuary, they were looking for signs of 'Denton's Spring', a historic well that provided fresh drinking water to a local mill in the 17th century. [They weren't] expecting to find much – maybe a large tree planted where the spring used to be. After all, the neighbourhood had been levelled and all the streams filled in or buried almost 200 years ago. But [they] heard something, and just a few yards from where the spring used to be [they] found water trickling out of the corner of a storm drain [9:2]

The *DIY methods* portrayed in these quotes and the case study in general also speak to the type of *sensing* and *tools* used: from digital technologies – "I have the air caster app on my phone now that allows me to walk around the neighbourhood and immediately collect acoustic data as to the noise levels for different streets and create a colour coded trail map of wherever I walk" [1:312], to microbiology for "water testing and the genetic makeup of it" [7:42] to "sending remote-controlled cameras underground, injecting dye into known seeps" [8:8] and using the sense of taste to determine "It's fresh springwater!" [8:11]. *DIY tools* play an instrumental role for data collection but also as a way "to reassert control over a lot of the processes of enquiry that were taken away from me" [2:221]. However, DIY tools are also weighed against the same *standards* as *citizen data*: qualifications and regulations. Thus, DIYers also strategically frame *DIY tools* and approaches in terms of established standards.

An additional challenge for the *DIY method* stems from who the people taking initiative are associated to. The EPA indicates distinctions in 'credibility' between an "ad hoc citizens' group" and 'organised or institutional groups' that "have a process"; the latter receive more support: "I encouraged them, I think we gave them letters of recommendation" [5:5].

The distinction is based not only on the data-collection process and association to an organisation but also on the methods and tools employed: "[They use] balloons… with [their] unorthodox methods, some of the information might be… I mean, it's of interest"

[5:148]. However, it is these same methods which DIYers promote to promote enquiry: "the way to get people to ask questions is to encourage contact and unusual behaviour, and having people canoe on the Canal may constitute unusual behaviour, but it will lead to more questions" [1:409]. The emphasis is on *interaction with the environment* and *exploration*: "doing hands-on things and being able to make that connection with that hands-on issue of improving the Gowanus. [7:32].

Reflections from facilitators reveal that while *enquiry* and promoting is at the heart of their work, it is not the main reason or condition for engagement. Another reason is *providing proof*, which has strategic importance to achieve their individual/organisational goals. I discuss this next.

13.3.3 Action: Providing proof

Completely embedded in the context of the Gowanus Canal, *DIY science efforts* are about *providing proof*: evidence from investigative efforts to gain support in achieving a goal. *Providing proof* is a salient theme linked to *enquiry* and *courage*. As part of the *DIY method*, *providing proof* is performed through *data*, requires *DIY sensing*, deep *local-* and *technical knowledge*, and is motivated by *being challenged* or *dismissed*. It is also revealed through personal *anecdotes*.

Providing proof represents two main functions: defending a position on an environmental issue and as a way to verify findings. An interviewee comments on their interaction with an investigative reporter:

> …she was like, "Mm-hmm, yeah, right," and then her eyes started to change when I showed her the actual pump pumping hundreds of gallons of water out of someone's basement and it was like – it's proof! Right? and it was also proof for myself because I had my own doubts and by someone challenging me, saying, "You're full of crap," I'm actually forced to defend my ideas and say, "No, no, you can't say that, here, let me show you [2:4].

By sharing or presenting evidence (especially when contentious or new) the DIYer enters a process of *learning* from *confrontation* and/or *dismissal* leading to further evidence-gathering, which in turn leads to the development of more refined arguments, as an interviewee remarked in [2:326] (p.305), in line with Piaget's 'exposure brings growth' idea. *Providing proof* is also about getting exposure, which is perceived to help push agendas forward.

Analysis also brings to light that part of *providing proof* is about promoting ideas and gaining recognition by popularising evidence and the stories around it, especially at the individual level, as seen in [2:242] (p.303). The main avenue for this has been the media with over two dozen news articles online in the last three years about the specific citizen efforts carried out by one of the interviewed individuals and over 150 news articles about organised efforts by the Gowanus Canal Conservancy. The strategy here seems to be using media and social media to 'apply pressure' on the City: "it's a political issue that we're considering because […] that puts pressure on budget decisions" [1:4].

A broader part of the process of *providing proof* involves gaining *local* and *technical knowledge* coupled with developing strategies of building rapport and alliances, as mentioned above, and widely communicating results and interests/agendas. It also involves leveraging the knowledge gained to plan more efforts (e.g. experiments, engagement strategies, etc.), device tools and solutions, develop dissemination materials, and presenting it to authorities.

Proof as 'answers' to DIY enquiry into environmental issues are presented with extensive cross-referenced documentation. In one case DIYers presented 14 pages of hypothesis, proposed solutions, overlaid maps, and ground and aerial photographs cross-referenced with NYC OpenData to the EPA. This 'proof' and supporting documentation is equally weighed against 'expertise':

> [They do] some exceedingly interesting stuff; some of it is useful in a qualitative way – [their] concerns about underground streams and things like that. But [they are] not in a position to go and do actual hydrological studies and put it in a series of wells and really measure this in a scientific way. [They have] secondary indicators of things that [they] believe to be happening and so the information [they] produce is somewhere between anecdotal and scientific and it is not to say that… [They] *have* given us a lot of interesting information and it *does* feed into our thinking […] but it's certainly not apt to be definitive of driving any kind of policy decision. […] [They are] as active as anyone is ever going to be so we certainly enjoy working with [them] and resources that [they have] at [their] disposal – [they] produce quite a lot. [4:53; 4:75]

Persistence in providing *proof* together with 'developing relationships of trust' are two of the strategic actions of *lobbying/advocacy*, which I discuss next.

13.4 What is it all for? The nature of lobbying and advocacy

As noted throughout the previous sections, many grassroots and DIY activities are carried out for the purpose of achieving goals (e.g. fulfilling mission statements or getting policy action). One main action to achieving those goals is through *lobbying* and *advocacy*. Together, these are a salient emergent theme and involve *interactions* between *authorities* and *community groups* to *highlight issues*, engage in *dialogue*, and *debate* about *development*, *infrastructure*, and *environmental issues* in the Gowanus:

> …so what is happening is community groups –by finding better citizen data– can come up with viable alternatives that are attractive to city agencies because a) they save them money and b) they have the support of the community, and really what's happening is a dialogue, when we're establishing the civic dialogue between local data collectors and state funding agencies. And ultimately we have to remember the city is our city- there isn't really a division, it's not between us and them- it's really reconnecting what people want from their neighbourhoods [1:124].

Lobbying/advocacy is about presenting convincing arguments (with 'credible' *proof*), reaching out (to the public, the authorities, and other groups), building alliances/partnering, and rallying support. The challenges lies in bringing together "very much a mixed- mixed community groups with different interests, all shaping the [community]" [7:18]. *Lobbying/advocacy* is also about 'standing for what you believe in' and applying pressure on authorities by framing/highlighting common goals. However, *lobbying/advocacy* requires long term commitment and *persistence*, which in turn requires considerable effort: "…a lot of these community-based organisations are really run by one or two dedicated people, who are tired, because it's a huge job –especially if it's successful" [6:71]. Some lobbying takes on a 'neutral stance':

> [P]olitically, our approach was to be politically neutral. We weren't directly activist, even though our sub-text was kind of activist, but we just did it through information, and also juxtaposing things, like a book, and an object, or an art, … it was more like you come in and you make those connections yourself. We weren't saying, "don't develop the Gowanus!", but we were showing through our exhibits the history, and the science, and so it was more like a sub-text. We weren't active politically, particularly. But that doesn't mean we didn't have strong feelings about it [6:43].

However, from the state's perspective what is being lobbied for "is not necessarily something that is being applied to a core problem" and they are cautious because "there are no metrics to figure out whether or not it is working" [4:43]. This marks another tension between the way citizen/community groups frame their approach and carry out their efforts, and the way

authorities frame and perceive those efforts. This tension is exemplified in this community organiser's comment about *funding*:

> The part [that] was the hardest, was fund-raising, when you're a non-profit, you can apply for grants, [but] that was hard because nobody understood, none of the grant-givers could- we weren't art, we weren't this, we weren't that, we were *everything*. So you can't encapsulate that into a grant proposal, it's just impossible to describe. [...] It didn't fit, it wasn't categorisable. [6:104; 6:144]

While the tensions between community and state expectations play a role in determining action, it is important to note that the interactions sustaining *dialogue* for *advocacy* are possible in the Gowanus because the state authorities themselves actively seek and portray openness to citizen input; they make themselves visible and available, and they put in place mechanisms, such as the CAG, to enable dialogue:

> In the case of the CAG […] in general it's an easy job, because it's a sophisticated public, and they are curious, they ask questions, and if they don't understand something, they are not shy of letting us know, and make us repeat or say it in a different way [...] sophisticated meaning that you have a concentration of highly-educated people, but highly-educated in other fields, not the science [5:129; 5:202]

This comment begs the question 'who is attending the CAG meetings and who is not' – clearly, an opportunity for future research. These state mechanisms/procedures are appreciated by community organisations:

> …in general the EPA and the DEP have been very supportive of community residents and … all their different feelings about the Gowanus and all their different opinions […] from the beginning they were very open to having community input […] I think especially with EPA there's a great community liaison, and [they] developed that trust between the residents and business owners and higher-ups in the EPA. Yeah, and [they're] basically at every single community meeting. […] There's been a lot of physical input- […] to submit a document from the organisation […] and they definitely look at those documents, it's not just a throwaway thing. [7:15; 7:17]

Another condition facilitating state-public interactions is the type of public engaged, and/or how the public is framed: By the EPA as 'highly educated/sophisticated'; by a local resident as trend, a people seeking for ways to engage:

> I think what's happened is industrialisation has become so successful that a large segment of the human population is obsolete, for a lot of their intellectual capacities are not needed and therefore they have to find another outlet for it. And so to a certain degree DIY science is also rec-, in some cases it's recreational science and in other cases it's self-empowering science [2:62].

This is in line with the trends in educational attainment set forth at the beginning of this thesis in section 1.1 (p.17). Over the years, many individuals have put in a considerable effort into addressing social and environmental issues around the Gowanus. Some have ceased, others are ongoing, and they are all equally celebrated and critiqued. Various reports and articles have highlighted the importance and 'soundness' of the grassroots approach to addressing environmental issues e.g. stream restoration: "The idea has enormous practical appeal. Why pump and filter water that is already clean when gravity would, with a little help, return the brook to its historical outlet?" [8:14].

However, while disagreements about *how* to address these issues dominate and delay action to move forward, it seems that they all intersect at the connection to place: the Gowanus (with its diverse meanings) and the symbolic artefacts that comprise it. A blog post on the 'Gowanus Canal Flushing Tunnel Centennial' celebration emphasises the value of community, support, and connection:

> Back then, the Gowanus Canal smelled. The Gowanus still smells. Back then, people were debating about what to do about the Gowanus Canal. You could say that it's kind of depressing that we are gathered here today to celebrate the anniversary of something and the Gowanus Canal still stinks, you could say that it's a sign that no progress has been made. I like to look on the bright side and think that it's a great thing that I have so many people here to celebrate the 100th anniversary of a giant plumbing device [11:2].

In the next section I present the substantive theory on citizen initiatives in DIY enquiry in a place-based context, thus offering a theory for the phenomena observed in the 'DIY enquiry scene' in Gowanus Canal. In Chapter 14 I also present a conceptual model for DIY enquiry based on the concepts from this and previous case studies (Fig. 14.4, p.348).

13.5 Integration and core concepts

Figures 13.7 and 13.8 illustrate the Grounded Theory for citizen initiatives in DIY enquiry in the Gowanus Canal. As with the previous cases, it is important to emphasise that this theory is grounded on the data and it is therefore specific to the phenomena observed during my visits and interactions at the Gowanus Canal. Within these bounds, the substantive theory produced accounts for the most salient patterns covering as much variation with as few

concepts as possible: the densest themes, their subdimensions, and their interrelationships. I outline a few opportunities for further research in the conclusions.

The process of integration in this case study was also aided by the construction of network diagrams. However, ideas and concepts from the previous case studies also guided the simplification and integration of core concepts.

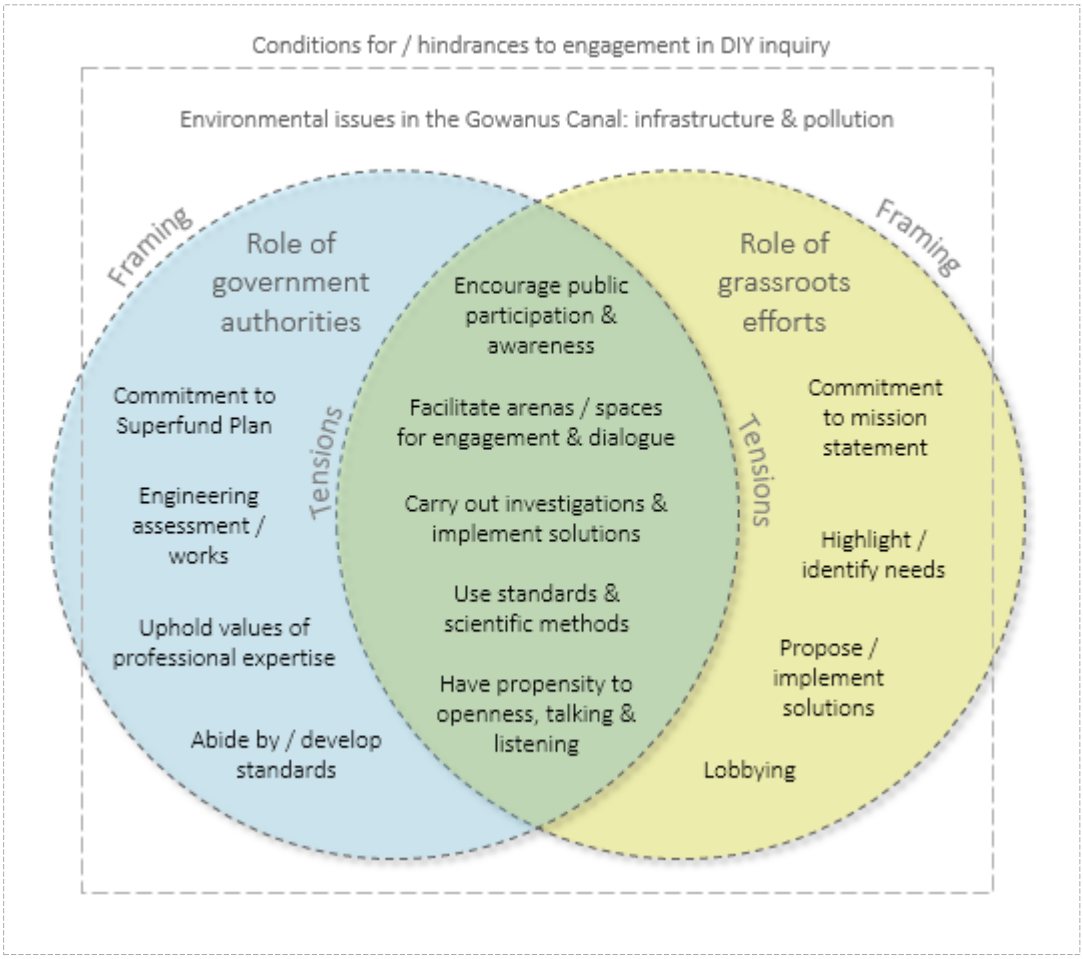

Figure 13.7 Grounded Theory for the case study of citizen initiatives of DIY enquiry in the Gowanus Canal: roles and framing from community organisations and the State.

The Grounded Theory for citizen initiatives in DIY enquiry in the Gowanus is illustrated in two parts: the interplay between the *framings* and *roles* of authorities and community organisations within the context of *environmental issues*, and the interplay between conditions and consequences of engagement that is in the foreground of framings and roles.

The Venn diagram in Figure 13.7 presents the role of community organisations and citizen efforts (grassroots) intersecting the role of government authorities. Each sphere represents

the framing adopted by each of the roles: community-based and institutional respectively. The intersection of the roles represents the activities and characteristics which both government authorities and grassroots efforts aim at or carry out e.g. encourage public participation. This intersection also represents the tensions between the two roles on e.g. framing of expertise. Both roles and framings are shaped by the environmental issues in the Canal but, the conditions and hindrances to engagement extend beyond its environmental context (represented by the external dotted line in Fig.13.7, p.313).

The tensions between community groups/individual DIY efforts and government authorities stem from the stances (linked to roles) and perspectives/framing they (choose to) adopt. Stances and perspectives are fluid and adaptive (hence the dotted lines) and are based on the strategies they develop as they strive to achieve their goals.

Both government authorities and community organisations aim at engaging and educating the public (to gain acceptance and to achieve change respectively). In both cases, they aim to gain understanding and support for their work/goals, as above in [5:84] "If you have understood it, and if you agree with it, then you're not going to oppose it". To achieve this, they both facilitate spaces and opportunities to engage the public but also do it in dialogue with each other. Both carry out investigations and develop tools, techniques, and programmes to support their work. These inform their approaches and solutions but are also guided by accepted standards and methods; for authorities it is the norm, while for organisations/community organisers it is the way to gain credibility/acceptance. At the same time, tensions arise from the way results from investigations are framed (against those same standards e.g. EPA objecting to DEP's "inaccurate factual misstatements" [4:37] and citizen data's provenance). Tensions also arise from the mismatch in timing and focus of aim (e.g. citizen data submitted at the wrong Superfund cleanup stage or focus on sediment versus pathogenic pollution). Finally, because both authorities and community organisations in this case study welcome and invite dialogue and openness, many tensions are eased. The arenas/spaces for engagement help both groups learn from each other's needs and stances. I had the opportunity to witness activists at a DEP community event bring with them but not use their protest banners because their issues were, at least in part, addressed.

Other research has shown that CAGs play a key role in easing tensions by enabling communities to have a formalised mechanism to voice concerns. Keyt (2010) writes "the role of EPA-designated CAG took a prominent place because they evolved from recognized

kinship and neighbourhood networks and held the trust of neighbourhoods suspicious of government representatives. The politicization of these networks into CAGs provided a formal system through which communities […] demonstrated the importance of their cultural identity and attachment to their home places" (Keyt, 2010, p. iv). However, these mechanisms are not sustainable; once the Superfund ends, the role of the EPA and CAGs will also finish and there is uncertainty as to what might happen to the networks and knowledge developed during the project.

The second part of the Grounded Theory in Figure 13.8 shows the interplay between the conditions and consequences of engagement. These are the backdrop of the role and framing of community organisations and government authorities. The bars in Figure 13.8 represent the salient actions and responses in this case study. The fuzzy ends represent their continuity. Colours have no bearing other than for ease of distinction.

The lower horizontal actions occur mainly at the personal level. Engagement in DIY enquiry begins with the ability to notice something (lowest level); becoming interested in knowing more and seeking more information (e.g. Googling it or 'poking around') occurs soon after. This leads to discovering/uncovering more 'clues' that capture interest (e.g. identifying a problem, finding people who are already addressing it, etc.). Continued engagement involves hands-on interaction with the environment (e.g. taking pictures of the canal, taking water samples, etc.) experimentation, trying things out, failing, trying again, learning, and developing and modifying tools/techniques. Noticing, becoming interested, and engaging hands-on begin processes of 'meaning-creation', gaining 'courage' (or getting discouraged and therefore disinterested), and devising 'practical tactics' (e.g. which apparatus to use, tree to plant, or street to explore) (represented by perpendicular bars on the left side of the diagram).

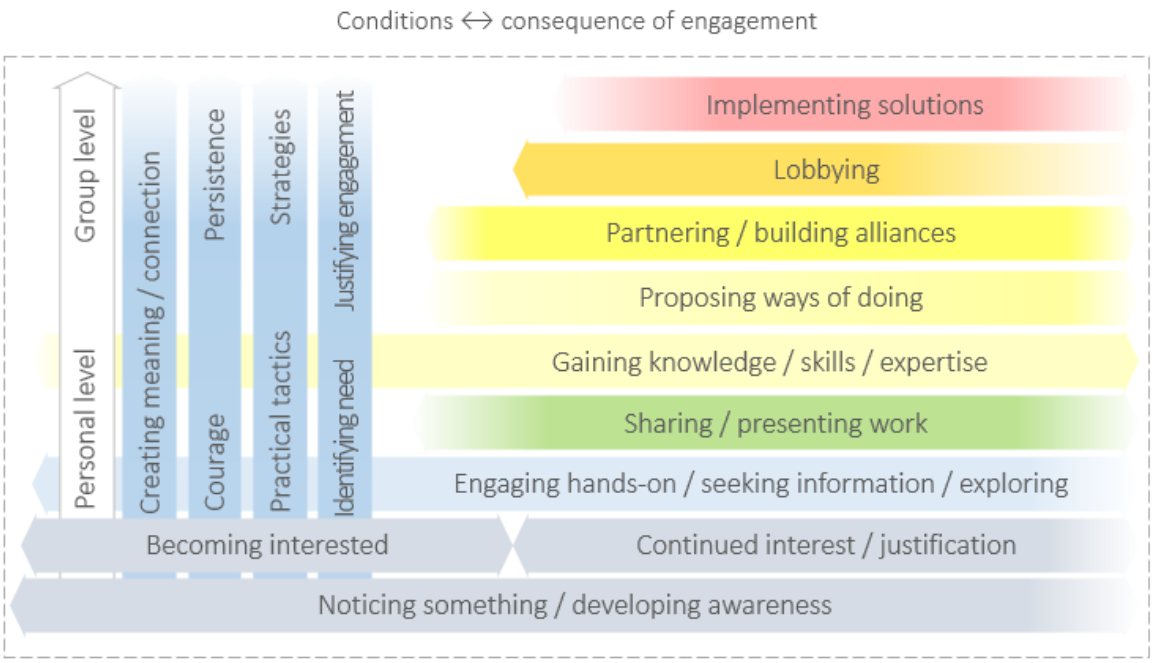

Figure 13.8 Engagement in DIY enquiry in a place-based context.

As the process unfolds, there is also interaction with others. Sharing work and ideas (in person or online) involves being listened to, seeking support, but also instances of being challenged, getting dismissed, and at times getting discouraged and even disengaged.

In some instances, being challenged leads to gaining further courage – to refute dismissals, learning further, and thus, 'gaining knowledge', skill, and eventually expertise (this is part of the 'hands-on' process, represented by the same length of the two bars). Part of gaining expertise occurs as consequence of having your ideas, stances, or techniques recognised/sought after.

Sharing work also involves engaging others, which in turn leads to further learning/gaining skills. This enables DIYers to propose new ways of doing/seeing things (e.g. solutions/alternatives to issues identified). As engagement in DIY enquiry continues, it gains recognition and/or bigger issues are identified.

Partnerships/alliances are sought for support to achieve a goal and/or gain legitimacy – moving more toward the group level engagement (represented at the top of the left-most vertical bar). 'Proposing ways of doing' things and 'partnering' involves having a stance (framing) and moving from developing tactics to advancing strategies (involving more people

and more commitment). Coupled with goals, stances become political agendas. Examples of strategies include building rapport, providing/presenting proof, preparing dissemination materials, contacting the media, choosing/leveraging frame of reference (e.g. employing standard data collection methods), identifying common goals, etc.

Lobbying occurs when specific changes to the status quo are sought; note that this type of engagement marks a turning point from 'becoming interested' to having 'continued interested' (or vested interest) (therefore length of bars 'continued interested' and 'lobbying' coincide). Moving from 'becoming interested' to having 'continued interested' simultaneously requires and creates 'justification' for engagement (e.g. time and effort).

Solutions are implemented at several points in the engagement process (therefore it is a bar with fuzzy ends). In this model its starting point is not so much temporal as it is the culmination of interest, expertise, support, seized opportunity, and persistence (coinciding with the upper part of the vertical bars). Throughout the process of engagement, there is creation of meaning and connection – to work, its significance and potential, to place and others, to values, and aspirationally, to beliefs about the future. Sometimes efforts cease, for example, when support, courage, and/or interest fails, or there is burn-out. These insights feed into the revised conceptual model for engagement in DIY enquiry (Fig. 14.4).

13.6 Case conclusion

This chapter has shown the results from qualitative data analysis on citizen initiatives of DIY enquiry in the Gowanus Canal and presented the Grounded Theory for this case study. Through this I have demonstrated the nuances of DIY practice and how it unfolds in a place-based context. I have built on the guiding concepts from previous cases including 'engagement' (process, consequences, conditions, reasons for-, and barriers), 'knowledge' (production of-, enquiry, and technical), 'DIY method', 'interactions' (with others and with artefacts), and 'connection', and I have found additional dimensions to these. This points to the tangible potential for further study in DIY enquiry.

My previous analysis of initial stages of engagement in DIY revealed that reasons for engagement are rooted in 'aspiration' to gain further understanding and connection and that this understanding and connection is rooted in meaning but also in uncertainty and

vulnerability. In this case study, the main initial prompt for engagement was the unacceptable state of the environment and the aspiration to do something about it. Engagement then continues because the focus is on getting that 'something' done. However, while contexts are different (workshop, community of practice, or polluted canal), engagement does seem to follow the general (but complex) processes in Figure 13.8.

While the previous case studies looked at the group (Public Lab community) and individual (playshops) levels, this case enabled an additional look at the organisational level in the context of 'place' and in interaction with other institutions. Here, the surprising finding is that 'roles' are adopted at these levels and that these define the framing of their stances and actions. In the other cases, the focus was more on the 'role' of facilitators and artefacts (e.g. artwork or DIY tools) as an essential medium for expression of and materialisation of experiences of engagement, enquiry, understanding, and identity. In this case, 'data', plays an important role as both a symbolic and physical artefact; it is in fact a medium to perform a 'role'. Specifically, it was surprising that the fact that 'citizen data' was being produced was not as important as how it was actually being used (and framed e.g. gathered using methods 'comparable to the state's own methods) and what it stood for: the potential to achieve a specific goal. 'Data' is a key symbolic tool for leverage.

Similarly, 'making' is not a prevalent theme as in the other cases. Rather, the focus is on what that 'making' is for and how it is used and done – that is, the goals and the strategies to achieve those goals. While in the Public Lab case, performing DIY was about questioning science and thus defining a community identity, here, the performance of DIY was adapted to the strategy of achieving a goal and thus 'not in competition' with or questioning 'science'. This is not to say that it is not considered a "self-empowering science", as noted in 13.4 [2:62]. However, here, the conception of DIY enquiry was extended through adaptive and 'frameable' strategic practices.

In this case study, interaction with the natural environment was more prevalent and thus, 'connection' is mainly to place (its history and social and environmental issues) rather than to community or to self. In all cases the connection was to meaning and symbolism. However, in the Gowanus, 'connection' was more salient in rhetoric as a 'need' and expressed in terms of 'disconnection' (i.e. there were more instances of the theme 'disconnection' than of 'connection'). In all cases, 'courage' remains a salient response and condition for engagement – courage to stand up and point out what is missing, courage to recognise when

you are in the wrong and when to stop, courage to listen and make compromises, courage to be political, and courage and persistence to create spaces and conditions for others to engage.

This case study has helped to establish ways of understanding and framing DIY enquiry in the real-world context of citizen efforts. Specifically, it has provided additional themes that point not only to the socio-technical but also to the socio-political aspects of DIY in practice. It enables a glimpse into the richness and complexity of experiences and factors affecting engagement in initiatives of DIY enquiry, which range from the development of techniques and strategies to the politics of advocacy and the leveraging of knowledge in interactions with authorities and different stakeholder groups. Further research should focus on what lies behind these strategies and politics as this will shed light on whether these are coincidental instances of 'community champions' or if the conditions for such passion, creativity, and dedication can be (re)created and nurtured. It would also be interesting to link this to the creation and nurturing of spaces and arenas for collaborative dialogue, understanding, prototyping, and action – e.g. are there sustainable versions of the CAGs and what pulls these forward (longer-term purposes, strong organisational foundations, etc.)? In the next chapter I discuss the link between the initial steps of engagement into DIY enquiry, a community of enquiry, and political engagement to answer the research questions posed in Chapter 7.

14. Discussion

14.1 Introduction: discussion of approach and method of analysis

This research employed a multi-method approach through three case studies. Here I discuss how each of the methods that were used facilitated a multi-dimensional and in-depth exploration of the various aspects of DIY enquiry.

My role through participant observation as 'complete member' enabled a unique and veritable insight into the inner processes and interactions of a community of DIY practice. This role enabled genuine exchanges and feedback from the community as insights were discussed with members of the community and considered part of its practice. Full acceptance and trust meant a reciprocal exchange as a way of giving back to the community, while contributing (and enriching) the academic perspective with insight gained. This research approach was useful in giving a longitudinal account of a community's journey from its formative years (in stance and approaches to technology, science, research, and outreach/engagement) towards organisational and infrastructural maturation. The insights gained (including the ability to interpret data) would not have been gained through other methods (e.g. by sending questionnaires or interviewing key informants). That is, understanding of creation of meaning (symbolically shaped over time) in the interactions between different members with different perspectives, expectations, understandings of a grassroots community making sense of, critiquing, using, and developing DIY tools while diversifying/(re)appropriating and defining techniques and collectively shaping its culture and identity.

In building a denser understanding of DIY enquiry, my role in a community of practice was complemented by 'researcher as facilitator'. This role enabled a hands on approach to designing and facilitating engagement in DIY through a workshop (playshop) series, which enabled an in-depth exploration of DIY enquiry at the unique micro-level of self. The development of 'playshops' as a mode of engagement that fused art and science with everyday experience enabled an exploration and purposeful acknowledgement of how people initiate their engagement in DIY enquiry. It also helped to understand how connections, meaning, courage, and technical competencies are initially developed, what maintains them

and inhibits them. Playshops facilitated a unique perspective into 'self' as enquirer and a critical examination of facilitation. It also helped to reveal the complex interplay between conditions and consequences of engagement. They provided a safe space to explore the value and process of reflective thinking, playfulness, and curiosity in the production of knowledge through interaction with self, others, setting, artefacts, meanings, and expectations. The most surprising aspect of the playshops was the use of artwork (by request of playshopers), which enabled an expressive form and process of simultaneous exploration / reflection / transformation of enquiry in everyday life. Research suggest, however, that because it is a unique approach, the playshops as a whole cannot be replicated. An interviewee noted the complex interrelations that made the playshops possible: "we [would] need to reproduce the conditions to create it […] The audience, the leader, the facilitator, the space, the background and also the communities […] with academical relationship, and […] scientific capital" [5:104]. Nevertheless, this approach needs to be studied further and complemented with ethnographies and authoethnographies to capture, in a targeted way, the 'nature of knowledge and transformation' in DIY enquiry, which could further shed light on how to design more inclusive and meaningful experiences with science and technology.

The final 'side of the prism' to understanding DIY enquiry was through a 'researcher as observer' approach which enabled observation of the setting as DIY enquiry unfolded in a place-based context between a range of actors. Research through observation with an explicit/formal role as 'academic researcher' enabled 'authorised' (or discretionary) access and interactions at the various case locations: EPA offices, community gatherings, sewers, etc. This key ability facilitated insight into the different perspectives on the same issue. That is, observation of the interconnected actions of development of techniques and strategies for tool development, data interpretation, and leveraging of knowledge and stance for advocacy from the point of view of authorities, community organisers, NGOs, reporters, academics, local residents, etc. An 'observer' approach only to studying DIY enquiry would not have provided the rich insights obtained with all three together. In particular, because the insight from the first two cases enabled me to develop sensitivity and focus necessary in a complex context of 'place'. The case also functioned as a way to compare and test insights between cases and in doing so, reveal assumptions about the all three, for example, why have a special focus on technologies which overshadows the culture of technical practice?

14.1.1 Convergence of themes in case studies: Insights from Grounded Theory

The use of Grounded Theory as a mode of analysis enabled theory to emerge from data collected. With very rich datasets and the topic of DIY enquiry undefined, the use of initial guiding concepts that stemmed from research interests and relevant insights from the literature provided useful preliminary focus. The rigorous process through various levels of iterative coding enabled exploration of bias through sensitivity analysis (through consideration of alternative meanings and interpretations of phenomena).

Iterative generative questioning and theoretical sampling enabled identification and saturation of salient patterns for the development of theory as an integrated network of salient themes and their interrelationship. In the exploration of DIY enquiry, an additional use of theoretical sampling is the comparison between different case studies. Figure 14.1 shows the overlap of some of the salient (but non-exhaustive) insights into DIY enquiry provided by the cases.

These overlaps were determined from the comparison of theoretical sampling and integration results between the case studies. The centre of the diagram highlights some of the most salient characteristics of DIY enquiry in all case studies. Additional salient themes include: an intrinsic curiosity exhibited by DIYers, the practice and recognition of the value of working with others, the process of reflective thinking as integral to DIY practice (regardless of the position of the purpose of practice in the continuum between means and end), challenging production of knowledge (at the personal, organisational, and socio-cultural levels), courage to take initiative and ownership over learning, development of personal and technical skills as tactics for enquiry, (re)shaping of identity, development of artefacts (e.g. as meaning and stance, tools, mode of enquiry), interaction with and sensing of the environment, hyper local context, acknowledging interconnectedness and appreciation of different ways of seeing and doing, attitude of being disposed to new ideas, and playfulness.

Insights that do not overlap e.g. 'workshop environment' in Playshops are not necessarily absent from the other cases, rather, they are highly characteristic of that particular case. Similarly, the overlaps between two cases, e.g. 'seeking actionable goals' between 'community of practice' and 'place' case study, are more salient in those cases. Interesting to note is that overlaps between these two latter cases are representative of DIY as a means – with

leveraging expertise, data, and methods for targeted oriented action, acknowledgement of politics and of diversity of issues shaped by those involved, innovation produced and sought, purposeful documentation and gathering of proof for lobbying.

The analysis of overlaps and divergences also helps in answering the research questions of this study. Some of these questions are implicit in the answering of the research questions, as the answers take from the perspectives gained from all cases collectively.

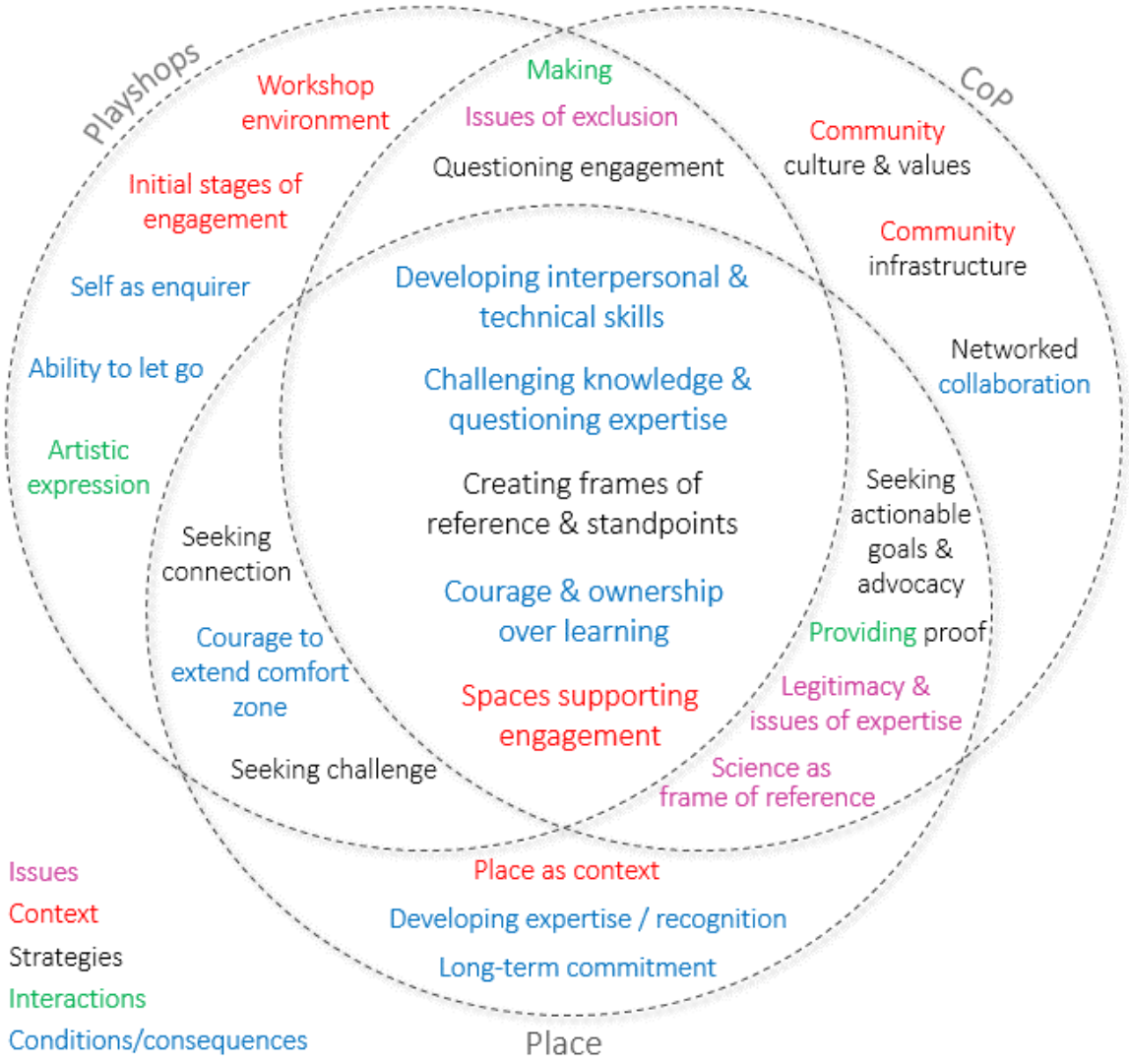

Figure 14.1: Salient insights into DIY enquiry emergent in the three case studies

14.2 Research questions answered

14.2.1 What is the nature of knowledge production in DIY enquiry?

Production of knowledge is both a process and an end goal in DIY enquiry. As a process its most surprising characteristic is that of uncertainty, which is evocative both of 'fear the unknown' and an exciting challenge. As an end it serves as evidence leveraged as proof to pursue actionable goals. However, it is an interplay between process and an end goal that production of knowledge serves as a narrative that tells the story of place and identity. It is embedded in practice and embodied, symbolically, and materially, in the artefacts the DIYers make and use. This is how production of knowledge serves a 'argument-by-DIY', shedding light on the *interactions*, *conditions*, *strategies*, *consequences* in the making of DIY.

The case studies also reveal that *knowledge* is at the interplay between *reflective thinking* (both at the individual and collective levels) and *production of knowledge* (as an object of reflective thinking and a process in itself). Production of knowledge is mediated by the object of reflection, itself determined by internal (e.g. values and socially-derived interpretations of internal and external factors) and external factors (e.g. social constructions of publics).

Reflective thinking is an integral part of DIY practice; it guides production of knowledge as people make sense of and ground their experiences. Findings support van Manen's (1977) definition of reflective practice (section 2.2.2, p.37) as a process of analysing and clarifying individual and cultural experiences, meanings, perceptions, assumptions, judgments, and presuppositions, for the purpose of orienting practical actions – at the individual and group levels. Reflection at the group level requires interactions which involve embracing vulnerability by sharing an opening up, as suggested by Brown (2010) and Piaget (1971). This willingness and ability to share reflect that lowering barriers to engagement is deeply personal. At the same time, reflective thinking is enabled through dedicated spaces, emotional and physical, perceived as safe, inviting, and fun.

The object of reflection remained similar throughout the cases: critical thinking about science and technology (methods and approaches linked to practice) and issues of inclusion, access, and purpose (by whom and toward what end), the latter as was highlighted by Brookfield

(1995), Flavell (1979) and Kolb (1984). Interviewees questioned their own knowledge; they weighed it against needs at the personal level or to achieve collective actionable goals. In the community and place-based contexts, reflections focused on the credibility of DIY practice, especially when stakes are high (it is more than only implications for the self).

We have learnt from the case studies that production of knowledge requires a sense of ownership, the ability to learn from mistakes, and being disposed to new ideas or possibilities, in line with Gerstein (2016) and Kolb and Kolb (2005). More specifically, it requires a sense of how different parts (of an experience or a process) fit together and this complements the notion on *schema* by Rumelhart (1981) and contemporaries. Knowledge is co-created through interactions – in workshops, community gatherings, and exchanges with stakeholders. It specifically benefits from building, making, and publicly sharing objects because, as Piaget (1971) proposed, exposure promotes exchange and learning. This highlights how production of knowledge in DIY is facilitated by common shared experiences, rhetoric, and practices, akin to Carlile's (2004) knowledge boundaries. In DIY practice shared experiences demystify DIY tools, methods, and practices as people develop new understandings. Coincidentally, these understandings create the foundations for new norms and culture that provide community memory, stability, and continuity for learning. They also make them more sedimented as community culture is normalised e.g. DIY aerial photography reaches closure or funding frames restricts goals. However, it is evident from the case studies that as it is the rigidity of institutional practice that DIYers and group founders are trying to contest, they have developed an awareness through reflective practice to try to avoid similar pitfalls as their communities grow – as was discussed in section 3.3.3 (p.65) on 'tensions from the institutionalisation of expertise'. This is not to say that they are immune and it remains to be seen how these groups evolve.

Following from this, the cases show that the factors involved in building knowledge are 'experiential learning' but also 'continuity'. Experiential learning occurs through hands on engagement and interactions that build connections and meanings, which in turn begin to build norms and practices. Continuity occurs through sequential or regular events, organisations, or a committed group. It supports experiential learning and the sustainability of a community/group/initiative by building personal and community memory (through mutual interactions – harmonious and conflictual – as suggested by Habermas (1984)). This is in line with Ross (2011), Kuznetsov and Paulos (2010), and Fischer (2011b) among others. Experiential learning and continuity are linked to the way production of knowledge is shaped

in the practice of DIY enquiry. Chidgey's (2014) suggestion to look at the way that DIYers internalise and externalise the social norms and values at group and social levels is particularly relevant; it reveals the structures that motivate and shape practice.

The cases also demonstrate that the nature of knowledge changes when DIY enquiry is specifically concerning environmental/social issues; the relationship between knowledge and data becomes central when the concern is to address a pressing problem or reach an actionable goal. In these cases, validity of knowledge, data, and know-how, take centre-stage.

Production of knowledge and reflective thinking facilitate initiative-taking. However, while taking initiative does require experiential and tacit knowledge, as suggested by Rumelhart (1981) and Kolb and Kolb (2005), it also requires courage. And courage is an essential part of the iterative cycle of in DIY enquiry, as seen in the model for concepts of engagement in DIY enquiry in Figure 11.10, p.267.

The case studies also demonstrate that DIY enquiry and production of knowledge gives rise to expertise, as Kuznetsov and Paulos (2010) argue. However, what has not been detailed in the literature is that expertise in DIY is manifested as both a skill and an attitude, which draws from and requires recognition and building strategic relations of trust to gain credibility, legitimacy and build rapport. The experiences from these also define identity. Additionally, the cases demonstrate that as part of the journey of exploration and initiative-taking there is a degree of uncertainty; it is part of the excitement of DIY but it is also the source of tension when the validity of DIY knowledge and data are questioned. This link is not explicit in current literature.

A key aspect of DIY enquiry revealed in my analysis is that it involves a deep personal connection because it opens up ways of doing, reflecting, and knowing – in our own terms. By trying things ourselves, we "go beyond our initial conceptions and open ourselves to deeper perspectives" (Reason, 2004, p. 5). The model on practice-based perspectives in Figure 2.1 (p.50) provides a valuable way of conceptualising the 'sense of connection' and ownership involved. In Appendix E.1 I present further discussion on how this practice-based perspectives model sheds light on the nature of knowledge production in DIY enquiry. However, what is missing in this practice-based perspective is the link to a macro-level of analysis. As I showed in Chapter 6, a combination of the SI micro-perspective and the structuralist SST macro perspective provide a useful framework: at the micro-scale, human

beings produce knowledge in an iterative process of interpretation-reflection through interaction with self, others, and artefacts; in this way, humans construct and reproduce society. This process creates ideologies, i.e. social constructions of publics and institutions. Thus, while DIY enquiry is rooted in deep personal connections, reflective thinking is also a product of socially derived interpretations of internal and external stimuli, as posited by Burbank and Martins (2010) and reflected in the revised model for concepts of engagement in DIY enquiry in Figure 11.10 (p.267). This micro-macro analysis also provides a key mode of analysis of the role of technologies discussed next.

14.2.2 What is the role of technologies in DIY enquiry?

In Chapter 3 I proposed that to understand the potential of DIY enquiry, what it does to people and what people do with it, we need a) to bring together (very eclectic) concepts and theories in the context of the digital age and b) an understanding of the preconditions for engagement in DIY enquiry and the link between enquiry and DIY technologies. To aid this endeavour and understand the role of technologies in DIY enquiry I proposed a multi-scale conceptual framework for technical DIY based on relevant literature (Figure 3.1, p.73). I now review this model based on the analysis of the case studies.

The **societal level** (macro-level, Fig.3.1) asks about the larger context that underpins DIY practice. Linking to the theoretical framework, and Habermasian theory, it asks what is technical DIY in response to?

Pinch and Bijker (2011) proposed that technology is embedded within the wider context of assumptions, beliefs, actions, and texts in our societies. This is clearly the case for the three case studies but most apparent where the place-based context is dominant and linked to politics and identity. However, not all of their model's assumptions (Table 3.1, p.59) hold in the context of DIY enquiry (section 3.2, p.57). For example, grassroots technologies are born out of heterogeneous and emergent social interactions, joy, play, wonderment, curiosity, and inspiration not only out of conflict, difference, and resistance. Additionally, not all 'protagonists' surrounding a technology are in dispute, disagreement, or confrontation; if they do deploy *strategies* these are not always to halt or impose an alternative version of technological and social relations. In fact, strategies in the DIY context are purposefully geared toward alliance building and leveraging positions.

Klein and Kleinman (2002) posited that rules, regulations, and standards impact how power is played out in the system. This is evident in the case studies, however, their proposition that these are so deeply ingrained they might not be so easily recognised, does not account for who is doing the 'recognising'. The cases show that DIYers and their grassroots techniques purposely aim at exposing and redressing these codified systems (e.g. purposefully (playfully) labelling DIY aerial photography as 'DIY satellite imagery'). Similarly, for De Certeau (in Feenberg, 2003), power is only tangentially at stake in most interactions and resistance is temporary and limited in scope by individual's position. While he is right in that to have impact people must group to collectively weigh in on the future design and configuration of the system and their products, these are not static; efforts are constantly trying "to reassert control over a lot of the processes of enquiry that were taken away from me" ([2:221] p.307) through actions, their tools, and their symbolisms.

In 'symptoms of the state' I asked (assumed) what technical DIY is in response to? However, from the empirical evidence I am compelled to ask if all DIY practices are acts of resistance and if all DIY technologies are political by default. As above, I found that not all technologies/techniques are political 'interventions' born out of conflict; there is also intrinsic value (in line with Nambisan et al. (1999)). However, as Weimar and Hecht (in Hecht & Allen, 2001) note, I found that beliefs, manifested as values/ethos/manifestos do shape (drive) real social and political change. And it is not only technologies but also technologists/facilitators/DIYers who perform 'expert power' through their symbolic beliefs (aligned to Hecht's (2001) *technopolitics*). However, this leads to question whose beliefs on DIY are the 'loudest' and which ones actually do have shaping capacity? Is it MAKE's and their promise of democratic and empowering technologies? But as I explain in in 14.3, 'responses' are an essential part of a synergetic process between system and lifeworld.

Linked to this and returning to the question why is that most references to DIY seem to evoke 'technologists' and 'tinkerers' (etc.) rather that 'scientists'? It does seem that 'Science' as symbolic belief of 'expert power' does shape how practice unfolds[29]: in particular in the community and place-based cases, where data and technologies are framed and leveraged to align with scientific conceptions to gain a stronghold and credibility. Interestingly, in the place-based case, community organisers do self-identify as citizen/community scientists –

[29] Further yet, (and perhaps a point for future research) I wonder if our strong focus on ideologies (beliefs) about technology is in fact creating an implicit assumption about their importance.

perhaps because the focus is environmental monitoring and data-collection to better the Canal (DIY as a means) as opposed to situating/proving a technology/technique (an end). Additionally, in the community of practice case, there is constant *and* simultaneous critique and redefinition of- but also dependence on science, as Tanenbaum et al. (2013) noted. These notions link to the next level, which focuses on expertise as symbolism.

The **institutional level** (meso-level) focuses on the symbolism of expertise and its effects on institutional arrangements and infrastructure design/use and leveraging of power from a 'strategic standpoint', linking to the 'status of science' (theoretical framework).

Jalbert and Kinchy (2016) provide one answer to what do people do with technologies and what do these do to them? They argued that tools can change the nature of 'public' because they affect practices and relationships, altering the means by which concerned citizens can participate in public debates. It highlights further questions: 'which people 'do" and 'what stance/power do they hold'? For the case studies it also highlights the importance of critically thinking about what the hidden interests/agendas of DIY community organisations and facilitators are e.g. what do we promise/assume about technologies and DIY culture and why? As participant observer in the Public Lab community I witnessed staff and organiser's concerns for, as Dunbar-Hester (2014) notes, openly recognising partialities and limited power/reach. Discussing exclusionary practices and developing/testing strategies to address them has become part of the community's practice (addressing Tanenbaum et al. (2013) 'paradox of standardisation' (section 3.3.3, p.66). This is not to say they have the answers and solutions to exclusion but they are following Dunbar-Hester's (2014) advice on not perpetuating power imbalances. It also links to my original concern about the role of the (academic) institution in DIY enquiry and highlights Storni's (2015) call for academics to practice a critical awareness of their political role as 'designers' leveraging our positions of power. The cases demonstrate that it is not only the role as 'designers' but as facilitators, leveraging the symbolism of expertise, materially and in practice. But here much remains to be done to challenge the 'professional status' and reach Haug's (1975) 'deprofessionalised' future (section 1.1, p.17) (if that is desirable) or answer Rydin's (2007) call for institutional mechanisms recognising multiple knowledges and technologies from below.

The case studies also highlight another aspect of symbolism of expertise: stance (position of power incl. organisational commitments) shapes the way technologies are framed. For example, authorities appraise DIY tools and citizen data and judge DIY techniques against

traditional standards while DIYers seek to gain policy action through their use and leveraging of data as part of advocacy efforts. Framing, however, is also stems from/is shaped at the individual level.

The **individual level** (micro-level) focuses on the factors influencing engagement with technologies and the conditions shaping 'tactical standpoints', linking to the theoretical model's 'self-trust' and 'cognitive and technical mastery' (from competency to attitude).

Smith and Fressoli (2016) proposed that in order for people to participate, 'notionally accessible' tools need to become actually available, and people need to feel confident using them. However, what is evident from all case studies is that 'notional accessibility' and 'confidence-in-use' require that both the technologies *and* the DIYers are transformed.

The cases show that 'DIY making' and giving 'material representation' to experiences facilitate and are facilitated by a cyclical process of creation of new frames of reference. 'Making' transforms DIYer and artefact and enables new understandings and connections. 'Making' is a continuous process that simultaneously develops, draws from, and requires literacy and competencies (social and technical), as suggested by Smith et al. (2017) and Barba (2015). Key 'competencies' salient in the cases are self-trust and courage, which enable 'cognitive and technical mastery'. The process of creating new frames of reference was most prominent during the initial stages of engagement in the playshops. It emerges as part of a larger process of transformation were people experience 'letting go' and 'extending comfort zone'. This supports Blikstein (2013) who argues that the real power of any technology is not in the technique itself or in the allure it generates, but in the new connections, forms of expression, interactions it facilitates and thereby the powerful ideas it makes accessible. Of course, this only applies to those who have access.

The cases also show that technologies function as both barriers and opportunities to engagement. When DIYers are able to engage with and transform artefacts/practice they further their engagement in DIY – enquiry, reflection, learning from mistakes, recovering from critique/failure, and experimenting with different ways of seeing and doing. When the DIYer does not engage/exert control, it can be said that there is disconnection and detachment, which gives rise to colonisation of the lifeworld as they capitulate to artefacts' dictated design/use.

However, a big question remains: can everyone engage in DIY? Or rephrased, is DIY for everyone? First, as Smith and Fressoli (2016), Haklay (2013b), Barba (2015) and others note, there are several requirements for engagement (cognitive, technical, social, etc.), which themselves require resources, time, access to spaces, knowledge, (peer) support, etc. Lack of these can hinder engagement. Second, but more subtly, the cases show that there is also a particular attitude and a perceived need driving engagement forward. Engagement, the cases show, is shaped by distinctive cognitive styles (Staudenmaier, 2001) and it is driven by curiosity and wonderment (these can be developed through engagement if barriers are overcome). However, as an interview remarked, when "I have no need for this in my life right now" (section 11.1.1, p.235) then DIY is deemed not relevant. However, the playshops case also showed that to know that DIY is 'not relevant for me right now', people first need to try it; the interviewee continued: "But what I do know right now is that if I ever needed to do anything like this, I know I can – and that, that is more valuable than anything". I discuss barriers and opportunities to engagement in more depth next.

14.2.3 What are the barriers and opportunities to public engagement in DIY enquiry, tool & technique development, and use?

Barriers to engagement can be understood through the requirements to engagement identified in the case studies; that is, what needs to be in place for engagement to occur. Requirements that are not met become barriers to entry and requirements that are present become opportunities. The most basic requirements are "time, money and x number of resources" [4:41] but engagement in DIY also requires certain attitudes and capacities e.g. initiative taking, patience, willingness to teach yourself, and imagination or visioning of possibilities. Barriers can also be understood through participants' reasons for engagement and through the way DIY is framed as I discuss below.

The cases demonstrate barriers at the personal, organisational, institutional, and social levels as depicted in the model for engagement in DIY enquiry (Figure 4.3, p.95). At the personal level barriers emerge as inhibitions mediated by past experiences and linked to expectations, judgement, and frame of mind. This is in line with literature on social work and education (e.g. Brown, 2010, 2012).

Also operating at the personal level, the case studies show that public engagement in enquiry requires connection, relevance to life/work, and willingness/ability to take on risks and to reveal oneself. Some of these aspects are recognised in the literature on public engagement, in particular the recognition of relevance to everyday life (e.g. Bonney et al., 2009).

The cases also show that there is a degree of skill needed to engage in technical DIY, as discussed in the previous section. Public Lab community members identified it as competence or 'manual dexterity'. They also noted that different skills are needed to engage in different parts of the organisation's work, as quoted in Chapter 8: "every time you add knowledge that must be implicit or that people must have before they can participate, you are narrowing the field of people who can participate which leads to exclusion" [1:85]. The cases also highlight that a main requirement for DIY *research* is access to information and to people who can share their experience and act as mentors, in line with Conrad and Hilchey (2011) and Kera (2012). Interestingly, it is very similar to what is required for 'successful *maker education*' (e.g. Gerstein, 2016). Specifically for knowledge creation in DIY enquiry, there needs to be a connection to people or platforms that can guide the sense-making process of what should and should not be in e.g. a sample of water. The ability to contextualise accessed information and results obtained through DIY enquiry is also seen as a requirement for engagement in research; knowledge provides the vocabulary to not only understand laboratory science and adapt it, but to build the connection that facilitates the DIY sense-making process and links to everyday life. Thus, some interviewees identify 'education' as a requirement for engagement; it provides foundational knowledge needed for deeper enquiry. This is a view held by proponents/supporters of 'increased science literacy' (e.g. Bonney et al., 2009; Silvertown, 2009; Wolff et al., 2017). However, interviewees also note that lack of access to knowledge can discourage people; there can be frustration from spending a lot of time trying to figure things out or looking at the wrong thing. The interesting point here is that this is especially true when there is a time-sensitive or pressing need for answers and solutions e.g. circumstance, needs, values hinder/enable how data or methods is represented by DIYers (e.g. Haklay, 2016; Nold, 2015).

The framing of DIY is a key factor in the identification of barriers or opportunities e.g. an interviewee noted that having a research question is essential to making engagement significant *for research*; an immediate risk or need is what gets data analysed to obtain answers and that it is this that links it to 'scientific knowledge production'. Here DIY is framed as a

means to drive enquiry forward while seeking to situate it within the realm of 'scientific knowledge production'. While Powell (2016) takes issue with conflating means and ends (or giving more weight to one over the other) in DIY/hacking practice, she does not make note of the intricate tactics and strategies employed in leveraging DIY as a means versus DIY as an end. It is about creating engaged communities while seeking actionable goals, which at the same time questions science, as noted by Lewenstein (2016) and Wylie et al. (2014).

Framing also highlights how a particular standpoint on DIY can preclude the identification of other barriers or opportunities. For example, Powell (2016) critiques that "for Public Lab, shareable knowledge is not an end goal, but part of the process that is intimately linked to making and doing. All of the legitimacy is thus associated with means, rather than with ends that could include an ongoing scientific conversation or the production of scientific data" (p.611). While she is correct in noting the interplay between knowledge production and making, her framing of DIY enquiry in its dimension as means of material and knowledge production precludes her from conceptualising it as end, which in fact is a building block in the sociotechnical infrastructure of the community. From within the community, it was found that the framing of DIY as a means (to e.g. fulfil funding commitments) focuses purpose, resources and efforts but it also precludes the rise of emergent and unplanned possibilities (e.g. because not all creativity can be streamlined).

There are also barriers that hinder a grassroots<->authorities relationship. For example, when creating data is seen as inherent to a tool (as noted by an interviewee), the focus on the iterative process of 'does this tool work?' is seen merely as a necessary step to achieve that goal; this undermines the value, depth, and opportunities of the journey of making – of DIY as an end itself. Furthermore, when DIY enquiry and production of knowledge are weighed against traditional 'scientific research' in the sense of 'we have discovered something new?' DIY or grassroots efforts are framed as 'not science'. Thus, what happens in the community is not seen as scientific research; it is seen as tool production and learning, which as noted by Powell (2016), exacerbates the imbalance in legitimacy between grassroots efforts and institutional science.

At the organisational level factors mediating engagement in DIY enquiry include having a culture and practices of inclusion – not only having them in place but having them acknowledged, promoted, and embedded in the interplay between techniques, tools, and ethos. This is absent from most public engagement literature but is alluded to in the DIY

and hacker literature (e.g. Chidgey, 2014; Kera, 2015; Ratto & Boler, 2014). The case studies also revealed that acknowledging that DIY operates at different speeds and trajectories (e.g. tool development vs. groundwork) is key to building organisational capacity because each speed and trajectory draws from different knowledges and requires different modes of enquiry. This is similar to Silva and Krasny (2016) who identify an opportunity in acknowledging, identifying, and creating a range of accessible protocols for enquiry that facilitate the building partnerships with professional scientists.

Linked to this but at the group or community level the case studies show that barriers to engagement arise when inclusive practices/norms are themselves the cause of exclusion of those who want to move at a different pace or have different technical requirements. In the case studies it is manifested as community fragmentation from mismatch between pace of activities, language used, and level of knowledge required to engage in enquiry. Reflective thinking at the community level creates organisational opportunities to examine taken-for-granted or 'sedimented' practices, where they stem from, and how they can be addressed or 'fractured' (Snow, 2001); see Box 3. When documented and systematised (e.g. technical and conceptual changes to the Public Lab platform (e.g. see p.181) this knowledge and practice builds legitimacy, addressing Beebeejaun's (2016) and Silva and Krasny (2016) concerns (sections 4.3.1, p.88 and 4.3.2, p.91).

Box 4: Organisational opportunities for & from practice

Several organisational questions arose during the collective examination of practice for Public Lab. For example, how wide a continuum for inclusion can an organisation want/handle? How are the needs and contributions of highly technical individuals addressed/valued and are they different from those of newly arrived DIYers? If so, how are those differences reconciled and learnt from?

One of the key points at the group or community level is the need to understand people's expectations and needs and if that is what the community culture would like to adopt. If, as Silva and Krasny (2016) note, these strategies (which are intimately tied to enquiry) are documented, they can also serve as ways to inform institutional and professional practice. At the same time, it was revealed that constant questioning of practices and process can also lead to loss of confidence in the group.

This research has reasserted that the notion that the more complex DIY enquiry becomes and the more is demanded of people, the less number of people become/remain engaged, as suggested by Hakaly (2013), Fig. 4.2. This is in line with Citizen Science literature on motivation (Curtis, 2015; Rotman et al., 2012). However, there is a more subtle implication:

dwindling engagement also means limited outreach and number of people engaging with, writing about, or sharing their experiences, and thus, less organisational memory is built. That volunteerism and financial sustainability are required to support engagement efforts is well studied in various fields. Another subtle barrier hindering the sustainability of organisations is the way their emergent approach or interdisciplinarity is interpreted as lack of focus, especially in the eyes of funders. At the same time it was found that groups that narrow their efforts may do it at the expense of the creative emergence that comes from unfocused engagement in enquiry. While literature in AR does focus on the pressures on 'emergence', the link to science enquiry is still elusive in the literature.

Requirements imposed by authorities (e.g. training and certification) also hinder engagement. Accordingly, community groups and DIYers frame their effort to fit authorities' expectations, satisfy requirements, and thereby 'level the conceptual playing field' of 'expertise' as discussed above. What is not clear from my research is when and how the strategies developed by DIYers (to frame, match, and therefore legitimise they methods and data in order to achieve policy goals) moves from 'matching for validity' to 'questioning to transform' science and institutions.

The cases reveal that at the social level, there are inherent barriers stemming from racial and socio-economic differences. These mediate social exclusion such as interactions with authorities. DIYers reflect on their privileged positions and on the barriers that disadvantaged groups might face when trying to engage in DIY enquiry. This confirms Douglas' (2016) study on DIY urban design (section 2.4, p.44); barriers at the social level are not directly addressed in the public engagement literature as they are in urbanism (e.g. Beebeejaun, 2016). There are also cultural and social pressures, and social inhibitions to engagement in enquiry such as appropriate behaviour, what to do and what not to (e.g. licking a rock or poking around in mucky waters). The strong overlap with existing literature is Dunbar-Hester's (2014) findings that while DIY practices opens up various avenues for enquiry, making, and expressing, it runs the risk of simply perpetuating power relations when not coupled with reflective practice that purposefully seeks to uncover its own assumptions. These are also concerns in the Social Studies of Technology seeking to bring to the fore the influence of structural factors (e.g. Bijker et al., 2012).

14.2.4 Can and how can barriers be overcome and/or opportunities exploited?

Opportunities for engagement that lower the barriers to entry and continued engagement in DIY have been mentioned throughout. Here I mention a few highlights and additional opportunities found.

Having a dedicated space (virtual, physical, organisational, intellectual, and emotional) arises as the main way to overcome barriers and seize opportunities for engagement. Spaces provide continuity and build memory as people work together, collaborate, and build on each other's work; spaces become conditions and consequences of engagement. This is in line with Gerstein (2016), Tanenbaum et al. (2013), and Kolb and Kolb (2005) (see section 2.2.3, p.39, on spaces for experiential learning). Within the organisational space, recognition of multiplicity of roles arise as an opportunity for engagement; the exchange between roles at different times during people's engagement enables an understanding of the organisations' work as a whole and an appreciation of the interconnectedness of roles. Linked to this, physical spaces for DIY enquiry encourage DIT as opportunities for creativity: there is exposure to and mingling of multiple ideas and shared access to resources, as posited by Piaget (1971).

Collective reflection and collaboration in safe spaces enables overcoming technical barriers. First, it enables communities of practice to acknowledge and discuss the limitations of their approaches and second, it encourages the group to collectively seek, prototype, and test ways to address issues of exclusion. It also enables them to assess and redefine their practices, culture, and values. For example, the way that the Public Lab community has addressed some of its issues of exclusion is by recognising and avoiding jargon. However, if jargon is part of the practice or some technical language and methods cannot be broken down or simplified, they create further welcoming spaces that demystify it and invite people to engage e.g. www.firsttimersonly.com, which promote a warm and friendly introduction into open source coding.

Space that promotes playful interactions lowers inhibitions through fun and enthusiasm, as was shown in the playshops case study and discussed in "Promoting playfulness in publicly initiated scientific research" (Regalado, 2015). Playfulness also creates value in DIY experience when combined with a purposeful medium for expression such as artwork.

Through play, experiences with DIY enquiry become enjoyable and enrich people's lives. Similarly, connecting DIY enquiry to an issue or a need, for example, an environmental issue to be solved, a tool to be developed, a deeper understanding of something not previously known, are opportunities that pull DIY enquiry forward.

The next section reviews the theoretical model developed in Chapter 5 to incorporate some of these salient issues.

14.3 Theoretical model revised

Habermas' (1986b) intention with his *Theory of Social Transformation* was to critique the 'social sphere' – the social illusions that promote and perpetuate ideologies of certainty and stability that give the system and status quo continuity – in order to understand the social world and guide social change by illuminating potentials for social change.

Following from this, the colonisation of the life world is conceived by Habermas as a process by which human agency and freedom are undermined by the mechanisms of the system. At the larger scale it represents the perpetuation of ideologies or social illusions e.g. about institutions 'for the common good'. While Habermas did argue that by critiquing these ideologies you also critique the illusion-forming institutions and that this exposes them and makes them more susceptible to change, he did not conceive of a reciprocal relationship between system and lifeworld. That is, while there is an encroachment of the lifeworld by the system, there is also an extraction from the system. If conditions are in place, there is a 'synergy' of appropriation (intended and unintended) from system into lifeworld and absorption back into the system (Figure 14.2). For example, Public Lab takes the principles and functions of a scientific tool, a spectrometer, creates an open source version of it 'at a hundredth of the price', and makes the blueprint and kit available on their website (absorption from and use of *system*). Then companies take these kits and sell them online (Figure 14.3) (absorption by the *system*). So, Public Lab responds to the lack of access to tools and viable methods for environmental monitoring by building their own and making them available (a *symptom of the state* & response to *status of science*), someone then capitalises on this and sells them online without the need to have met Public Lab or learn about its values, etc. (treating them as means to an end). But Public Lab designs their kits with guidelines and information that invite the 'buyer' to learn about its values, how to get support, and join its

community, thus Public Lab disseminates and normalises its practice and technical culture. That is, what has been absorbed by the system is not devoid of meaning and purpose, in fact it uses the system to disseminate its practices (and critique it) through text and the DIY tools themselves. In Figure 14.3 the interrelated factors influencing the 'colonisation of the lifeworld' appear overlapped to represent the blurred interrelations between these.

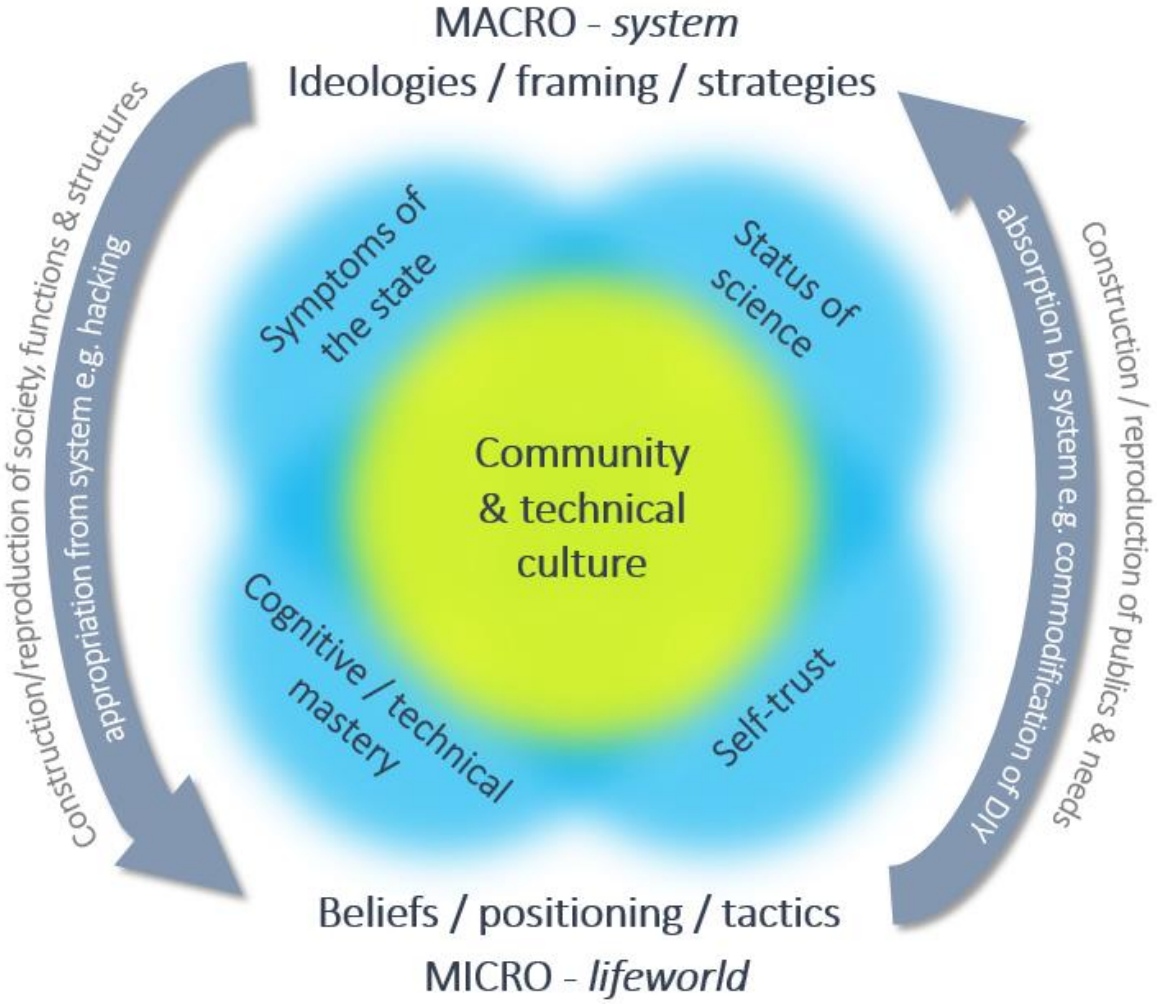

Figure 14.2: Revised theoretical framework on the factors influencing DIY enquiry. Synthesis of theoretical and conceptual models.

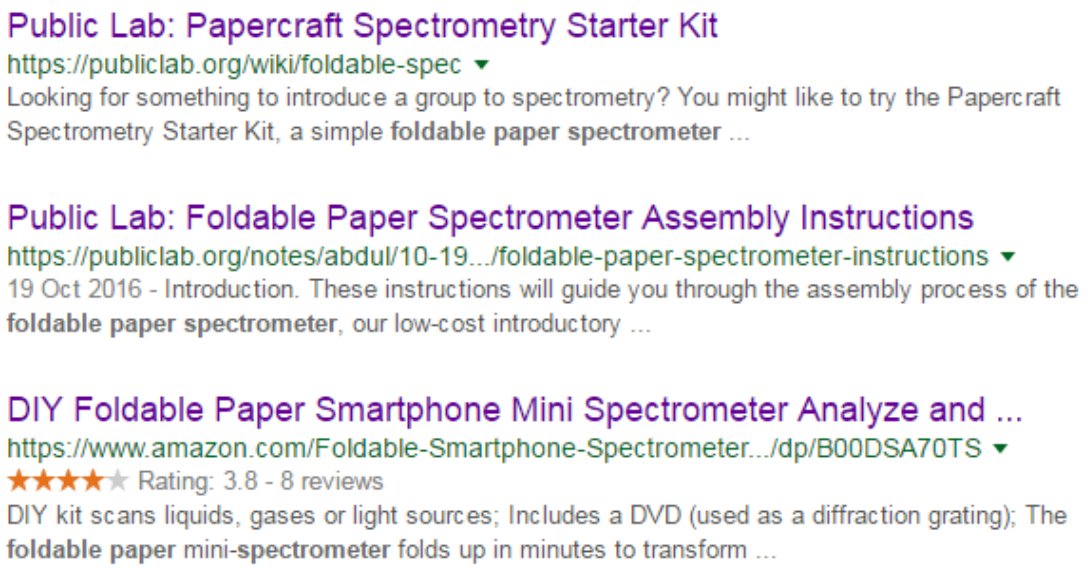

Figure 14.3: Public Lab foldable spectrometer web-search showing Public Lab's page and the sales page on Amazon

The mechanisms of the system in the digital age are enabling functions taken up by start-ups and NGOs as resources; they reappropriate their functions and meanings. For example, in creating Creative Commons against copyright or protecting grassroots' organisations status by obtaining an official designation that is recognised by the state (e.g. not-for-profit) they gain control over and redefine the legitimate power held by institutions. It is not only the system that extracts resources and meaning from the life world. The life world also takes 'resources' (symbolic, material, etc.) from the system (e.g. infrastructure, ideas, etc.) and transforms them. Habermas is right that for the system to continue to operate it is imperative that the lifeworld replenishes because the system takes 'resources' of meaning from the lifeworld and absorbs its functions. However, this replenishment does not happen in a 'lifeworld vacuum'; the lifeworld too takes from the system – and hacks it. Then Google and O'Riley Media takes these, commodifies them, and sells it back to us. This 'symbiosis' shapes the nature of DIY practice – its tools, techniques, goals. In fact, I argue that the interaction between system and lifeworld is essential to provide the sources and structures, "tools, interpretive frameworks, products and practices" that "constitute the social heritage that individuals acquire in their becoming part of a community and through experiential learning" (Certomà & Pimbert, 2013, p. 2); it is part of the complex process of production of knowledge. Habermas also saw the lifeworld as a space outside of the state arena of validation, normalisation, and assessment – outside of the generalisations of imagined publics – but in practice these mechanisms are also at play in the lifeworld. Whether the system-

lifeworld model makes sense still is the topic of future research but there is indication that this distinction is useful.

I now turn to reviewing some of the propositions made regarding the factors that contribute to the colonisation of the lifeworld – the theoretical model in Figure 5.1 (p.107). Each of the sections that follow represent the four quadrants of the model and each include a table with revised implications from specific challenges to DIY practice (Table 14.1 to 14.4).

14.3.1 Symptoms of the state

> *Symptoms of the state* facilitates an examination of the generalisations, at the societal level, about publics' interests, abilities, passions and hopes held/fabricated by 'experts', society, and various publics themselves. It also helps us to unveil, as we shall see below, the hidden ideologies of a culture or practice and the socio-political discourse that shapes it and is shaped by it.

Wynne's (2007) critique on the institutional approach to determining what qualifications 'the public' should have to engage with expert issues or how much they must be educated or trained to 'bring them up to standard' holds, as the Gowanus Canal case study demonstrates. Authorities 'hide' behind assurances of liability and dependability and their claims supported by standards and codes as argued by Wynne. However, in contrast to Wynne's assertion, in determining what the 'relevant public issues' are, the establishment of CAGs and dedicated community liaison by the Gowanus EPA does demonstrate a move toward recognising the value of public engagement and integrating public values into public debate as Rowe (2005) posited. In-depth research into the actual functions of the CAGs were outside the scope of this research but based on extant data, it is evident that the CAGs and the EPA's strategic attendance to all community meetings are a way to recognise the diversity in grassroots and DIY initiatives. Their intensions are not known but contrary to Beebeejaun (2016) and Stilgoe et al. (2014) it could be seen as a way to avoid 'marginalising and masking' diversity – or at least avoiding controversy (Table 14.1). The EPA's initiative-taking and approachability has in fact promoted engagement in processes of citizen-led enquiry. This particular EPA team might be an isolated case but they do share their practices at bigger EPA conferences.

Another proposition that holds is that to gain recognition, groups need to amass success stories as cumulative evidence of their impact. Public Lab and the community organisations in the Gowanus case demonstrate this. However, they not only document their work, they also transform it and manipulate it, and leverage it to achieve actionable goals.

Table 14.1: Symptoms of the state: challenges and implications for DIY practice

Challenges for DIY	Implications
Ideologies portraying a *generalised public* stemming from state definitions on 'acceptable public competency', public issues/concerns/needs, valid knowledge & expertise backed / enforced by standards & regulations 'for the public & common good'	• Perpetuation of an approach that marginalises and masks the diversity in grassroots and DIY initiatives • Deprives people of influence and importance • Deprives people from belief in that they can and should take control over issues around them • Prevents people from beginning and therefore engaging in the process of citizen-led enquiry • Identification of ideologies/sedimented beliefs can pinpoint power imbalances and potentially transform them
Implications of *ideology* on practice – how politicians, cultural critics, policymakers, etc. leverage symbolisms & relationships between power, authority, & technology (e.g. professional & scientific evidence)	• 'Strategic' marginalisation to avoid controversy • Reproduction of discourse and symbolisms of technological power • Citizen-led enquiry into generalisations can critique, learn from, and shape them; critique of generalisations can also help citizen initiatives to critically examine their own practices
Issue of *recognition* as expectations from ideology	• Recognition requires documented cumulative evidence of impact of DIY/grassroots efforts; documentation also helps to transform practice • DIY initiatives emerge as responses questioning the system, challenging societal structures, and taking issues into their own hands • Grassroots initiatives seeking to forge alliances & partnerships with authorities & other stakeholders • Leveraging of stance, reframing of methods and data • Extraction of good practice decontextualises it and contributes to generalisations about communities, places, and initiatives

The framework elements of 'symptoms of the state' can be conversely applied to the examination of DIY practice itself (not only institutional practice). For example, if the contents of a particular culture or practice (e.g. living off the grid) are treated as an ideology that reflects the concerns it stems from (see Box 1, p.101), that is, if it is seen as a determinant

response to socio-economic and political issues (e.g. as response to pressures of capitalism), then we are able to seek and find in that practice the resources to expose or address the problems of that society (e.g. alternative modes of energy). This scrutiny is not only an analysis of the content of the ideology (e.g. examination of the privilege of being off the grid) but is also an analysis that reveals its origin and motivations (e.g. political ethos and being self-reliant). With this framework we become compelled to ask: what are the ideologies of DIY practice and what do these reveal about their concerns/interests? But also whose ideologies are being played out and dominate practice (i.e. whose DIY)?

14.3.2 Status of science

> *Status of science* facilitates an examination of the institutionalisation of expertise, including the way 'science' is perceived by practitioners of science, the state, and the public. It also helps us to ask questions about the relationship between knowledge and power and role of knowledge in creating barriers and opportunities for engagement.

The mystification of science and research is evident in the case studies; remarks such as "oh, I'm not a scientist" were common. But the cases show that the creation of and participation in spaces for enquiry do serve to link science to everyday practices and dispel these notions – and even lead the questioning of and strategic use of science and expertise. The notion that professional science has achieved the status of illusion perpetuated by discourses on canonical expertise that results in its legitimacy as the singular authoritative voice informing policy, is however, clearly evident in the Gowanus case study; authorities do not question their status quo and in fact hold others accountable to it.

Habermas' 'critical oriented enquiry' manifests itself almost exactly in the Gowanus and Public Lab cases: there is a "calling into question, and deep-seated wish to throw-off, relations which repress you without necessity" fuelled by "a desire to assert the possibility of greater autonomy and responsibility" (Habermas, 1986b, p. 198) as expressed by a community organiser in the Gowanus about the role for data collection as a way "to reassert control over a lot of the processes of enquiry that were taken away from me" [2:221] (section 13.3.2, p.307).

Table 14.2: Status of Science: challenges and implications for DIY practice

Challenges for DIY	Implications
Professionalisation of expertise supported / promoted by institutional arrangements for testing, validating & disseminating (e.g. credentials, regulations, funding schemes, protocols, etc.) & exclusive spaces & voice	• Discouragement of engagement in science because feeling 'not up to standard' • Capitulation to symbolisms of 'Science' • Same hierarchical/bureaucratic structure giving stability/continuity to scientific endeavours hinders the questioning of the structure itself • Provides continuity and efficiency • Provokes grassroots responses challenging status quo
Ideology of 'the superior public knowledge for the greater good' linked to Micropolitics of power: technologies as instruments to build networks of influence, over time fixing meaning / symbolism of power	• Access to/inclusion in technological frames mediated by ideology about status of Science • Leads to closure/obduracy of technologies for enquiry defined by goals, interests, skills, etc. of relevant groups 'included'
'Canonical science' is the *frame of reference*; problem-solving / decision-making dominated by institutionalised & professionalised practices	• Attitudes toward/assumptions about public's (lack of) expertise or perceived indifference/apathy toward science perpetuates (paternalistic) power relations • Hinders understanding of complexity & multi-scale of emerging problems • Hinders conceiving new problem-solving methods within the institution; leads institutions to reach out to community groups – to seek acceptance, resources, & alternatives • Excludes creativity, skills, & competencies large portion of the population; marginalises different ways of knowing • Critical enquiry reveals patterns and meaning that reproduce structures of power so that these can be open to challenge and change • Grassroots science proposing/practicing a multi-actor process of enquiry • DIY practices as response seeking to question/redefine science & technology thereby providing alternative approaches

What is salient and new from the cases is that, coupled with the marginalisation of different ways of knowing, the 'status of science' poses an additional challenge to DIY enquiry when 'canonical science' is *the* frame of reference (Table 14.2). The hypothesis here is that, in response, DIY practices seek to question and redefine science and technology and in doing so, provide a varied array of approaches. However, it still holds that the lag in

acknowledgement of different ways of knowing as valid knowledge claims means DIY enquiry is measured against canonical science; there is nothing else to measure it against, as posited in 5.3.2.

14.3.3 Self-trust

> *Issues of self-trust* facilitates an examination of the discourses that the public, as individuals and groups, produce and reproduce with regards to initiative-taking and ownership over issues. It also enables us to ask questions about the implications of those discourses on people's actions.

The main contributions to the theoretical model on issues of self-trust were put forth in the revised model for engagement in DIY enquiry (Figure 11.10, section 11.7.1, p.267).

This framework element sought to understand the discourses that the public, as individuals and groups, produce and reproduce with regards to initiative-taking and ownership over issues. A 'practice-based perspective' recognises the focusing on common experiences, discourses of empowerment, and recognition of difference as integral to articulation of identity and belonging. The case studies showed that this does facilitate the process of enquiry – of ownership over learning and action, in particular, in the creation of safe and welcoming spaces. In fact, it is in these spaces that, through group discussions, collective reflections, collaborative prototyping, etc., there is a move from DIY to DIT, which facilitates engagement with wider questions about race, class, gender, and power. This in turn shapes identity in a iterative process of adaptation, sedimentation, and transformation, shaped by factors such as interactions, interpretation of expectations (internal/external), goals/purpose, values, etc.

An interesting aspect of DIT is that validation of knowledge implies a validator and a set of 'criteria' against which knowledge is authenticated. Therefore, if treated as a social product, knowledge requires a consensual basis; traditionally, people who find no one to agree with them are pushed to the margins (Friedmann, 1987). (Co)production of knowledges and artefacts requires not only the stability of trust and common lexicon, meanings and interests, but sharing a vision for change, faith in uncertainty (Shiela Jasanoff, 2004), and embracing vulnerability (Brown, 2010).

Table 14.3: Issues of Self-trust: challenges and implications for DIY practice

Challenges for DIY	Implications
Neoliberal restructuring of society and economy	• Neoliberal capitalist logic favours capacity for consumption over capacity for production; language of 'clients' and 'consumers' replaces that of citizenship; civic viability (or ability to take initiative) becomes mediated by ability to consume • Stifles a pathway into the process of enquiry and the creation of identity and sense of belonging and therefore of 'making' and reappropriation of technologies and methods of science
Implications of *ideology* on self – how people in positions of power & authority construct the public	• Social constructions of the public can shape identity and action; notions of the public as ignorant, irrational, and incapable may be internalised and can stifle initiative-taking and reproduces / perpetuates this ideology • Meanings assigned to 'lay' and 'expert' define people's roles – in self-definition and to portray it to others to gain power and control (perpetuating knowledge hierarchy) • Response to issues/circumstances; technologically-oriented DIY activists seek to produce technological artefacts & egalitarian social relations that purposefully erode boundaries between experts and 'lay people' • Reflective capacity developed as part of practice enables both empathy and internalisation of other's conceptions
Confidence determined by attitude toward & beliefs about technologies	• Deep engagement; sense of being in charge and exercising control equals reduction in perceived difficulty in technical engagement; excitement about available possibilities • Critical enquiry: DIY tools and techniques do not in themselves address issues. However, they do help people ask questions and make issues more visible • 'Tinkering as enquiry' promotes hands on questioning people's relationship to their environment

14.3.4 Cognitive and technical mastery

Cognitive and technical mastery considers the multiple levels of mastery and mechanisms that enable contribution to and manipulation of the system.

Reflective thinking about technologies (individually and collectively) reveals the politics and inherent mechanisms of exclusion embedded in technologies. Reflective practice in the

design, use, and teaching of tools and techniques in the Public Lab community acknowledges this. Beyond this, individuals and organisations in the case studies also acknowledge the power of framing technologies (as symbolisms) and develop tactics and strategies to leverage them to advance action.

A defining characteristic of mastery in DIY is that through the reappropriation of technologies, as individuals or as a collective, people gain the ability and momentum to respond, engage in dialogue, and take action. This type of mastery simultaneously enables and requires flexibility and emergence, equivalent to curiosity driven (or blue sky) research. Hence, 'ability to respond' highlights the self-reliance ethos of taking control of our own lives (Emerson, 1841; Rahman, 2008; Wehr, 2012). As a form of mastery and autonomy, 'ability to respond' also stems from and builds (self-)trust. With this understanding of autonomy technologies are not mere signifiers of self-reliance – technologies are claims to knowledge in themselves. Additionally, achieving mastery and autonomy requires building iterative courage and skills, access to resources, and commitment, as discussed in 14.2.2.

Table 14.4: Cognitive and technical mastery: challenges and implications for DIY practice

Challenges for DIY	Implications
Implications of *multiple levels of mastery* and mechanisms enabling contribution to & manipulation of the system stemming from privileged access	• Active construction of equitable systems and infrastructure for participation/co-creation • Gaining significant control over system requires acquiring more complex skills (greater technical and cognitive mastery), time, and resources incl. infrastructure that builds and is supported by institutional capacity • Control over system requires institutional capacity, which is prone to rigidity and exclusion • Access and system control still limited • Creation of welcoming environments that support learning & initiative taking
Implications of *ideology* on practice – how *tools are democratising* production of knowledge hinging on ideals of participation and access for anyone, anywhere, anytime	• Continued assumptions about infrastructure as neutral, apolitical, ungendered, etc. overshadowed and perpetuated by (media) hype • Democratisation assuming a generalised notion of society: everybody shares the same truth, values, & life experiences

14.3.5 Revised concepts on engagement in DIY enquiry

With these considerations we can now turn to reviewing the factors that contribute to the possibility of DIY enquiry: what do practices of DIY do to people and what do they do with/through DIY practice? Here I advance the concepts of 'engagement', 'courage', and 'community' proposed in Chapter 11 (Figure 11.10, p.267) and extend them to community of practice and place-based DIY enquiry, as shown in Figure 14.4. These concepts are not mutually exclusive nor exhaustive. As noted in Chapter 7, forging formal (or more comprehensive) theory requires further theoretical sampling in a wide range of contexts.

I argue that *engagement* in DIY is at an interplay between structural factors (e.g. standards, policies, mandates, etc.); settings at the smaller (e.g. safe and welcoming spaces) and larger scales (e.g. social setting promoting engagement with science and technology); and interactions within DIY enquiry practice (e.g. interactions with peers and tools) and external to practicing groups/individuals (e.g. interactions with state actors, academic researchers, etc.). Interactions and responses are negotiated in, shape, and are shaped by structural factors and settings (blue double arrows Figure 14.4) but also by individual attitude and community culture, hence the arrow of 'engagement' flows toward the centre of the figure. The light grey arrow exiting 'engagement' represents the situations when some structural mechanisms, settings, interactions, or combination contribute to exclusionary circumstances/mechanism (e.g. extractive research or persistence of imagined 'public needs').

I argue that *courage* in DIY is at interplay with attitudes. For example, playfulness and reflection promote the courage to engage with DIY – to dare, experiment, fail, learn from failure, etc. Additionally, courage simultaneously builds and draws from tacit knowledge and competencies; it also builds and draws from self-trust. Together, these stimulate and nurture collaborative attitudes and exchanges that promote group trust, community, and further engagement (hence 'courage' arrow flowing toward the centre of the figure). Not all engagement in DIY enquiry is enriching. Sometimes there is a mismatch in expectations (internal and external to self) and a lack of connection or relevance (grey arrow leaving 'courage').

I also argue that *community and technical culture* is at interplay with the resources it creates/receives/enables (e.g. online platforms, techniques, interpretive frameworks shape practice *and* embody values, meanings, tensions, etc.). The focus here shifts from

'technologies' to 'technical culture' because technologies are embedded in practice: technologies and their concomitant techniques and what they signify are embodied, symbolically, and materially, in the artefacts that DIYers make and use. DIY techniques at the group/organisational level represent a technical culture; these symbolise, shape, and draw from individual and collective imaginaries, values, and claims to knowledge. Community practices, tools, and techniques represent potential alternatives to local issues. They also present opportunities for complementary partnerships and alliances (e.g. blurring conceptions of expertise, validity, empowerment, etc. in the local context when there is mutual learning between community organisers and licenced professionals). But maintaining community requires politics, creating strategies, commitment, access, support, etc. which are often sustained by 'community champions' who can burnout or whose circumstances in life can change. Purposes also change as do practices, hence the grey arrow exiting 'community and technical culture'.

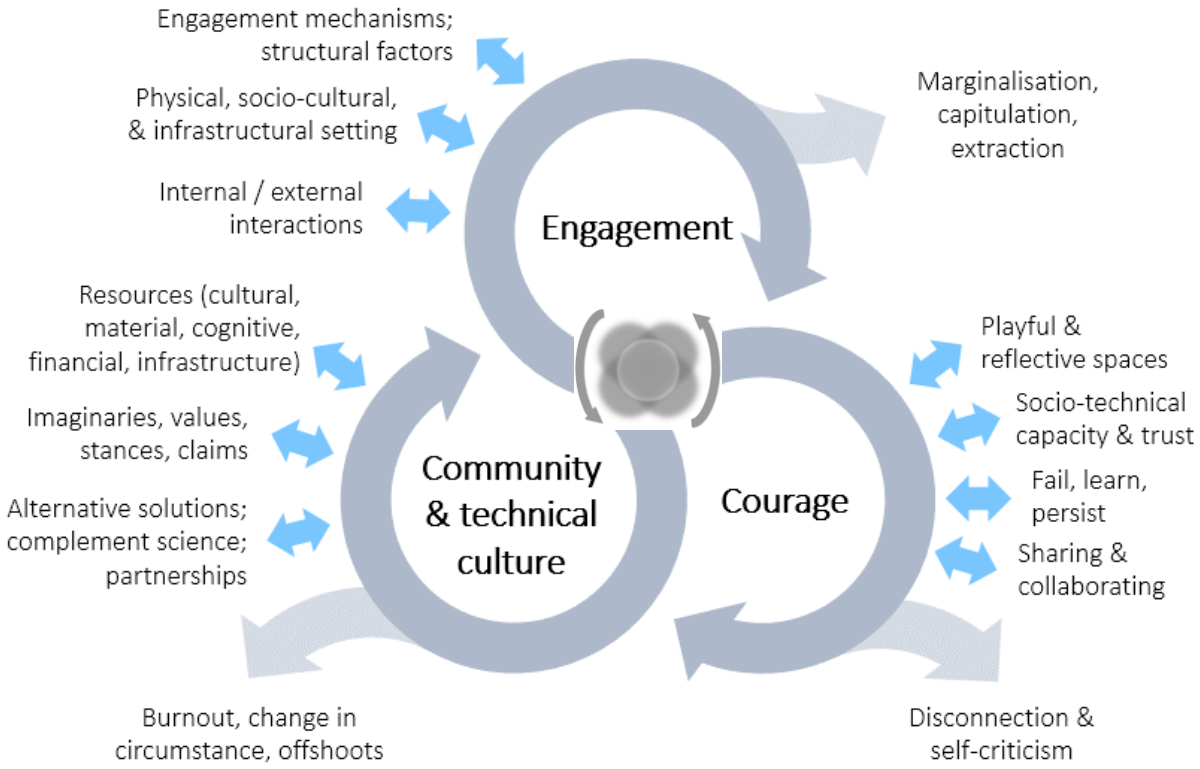

Figure 14.4: Revised conceptual model of engagement in DIY enquiry.

As with the previous model (Figure 11.10, p.267) 'engagement', 'courage', and 'community' are influenced by a complex interrelation of micro and macro conditions, circumstances,

functions, and framings. Hence, the theoretical framework sits at the centre of this revised conceptual model. Connecting these models also illuminates Irwin's (2015) question 'in the name of what is public engagement being done – ideals or realities?' It is not only about macro ideologies/framing/strategies and micro beliefs/positioning/tactics (Figure 14.2, p.338); it is also about how these play out in real practice, cognitively/semiotically and materially.

I now move onto the final chapter: summary and conclusions.

15. Conclusion

15.1 Research approach, methods & cases: summary & reflections

DIY is as unique as each DIYer, it is ludic, and often feels daring. What characterises all of DIY is a sense of self-reliance and ownership over experience. But while the essence of DIY starts with self: self-reliance, self-learning, self-satisfaction, DIY also unfolds uniquely at the level of community and when it is deeply embedded in place. I defined DIY enquiry as ownership over learning and action and argued that it is through ownership over experience in the process of individual and collective enquiry (i.e. exploring, seeking knowledge, figuring things out, experimenting, and questioning the state of things to find potential solutions to local concerns) that agency is kindled.

This research comes in response to assumptions behind the promise of 'new technologies ushering in a democratisation of science and technology' and a shift in the redefinition of who can do science. It also tries to address the bias in the focus of Public Engagement and citizen science studies and to elucidate an underlying problem of inequality and exclusion in participatory approaches to science and technology. But this research also was motivated by my own journey into DIY: tinkering with DIY electronics, my first gathering with Public Lab, being part of a community of practice, appreciating and reflecting on the transformative nature of DIY at the playshops, and observing citizen-led strategies for environmental stewardship in the Gowanus Canal. Together, these experiences prompted me to investigate the phenomenon of DIY practice further. They enabled me to bring together disparate notions and conceptualise the different depths at which DIY unfolds.

Specifically, to shed light on the highly personal and experiential contexts of DIY enquiry in both social and technical senses, I explored the literature in three interrelated topics: knowledge, technologies and engagement. Following a funnelling approach, these literature reviews guided the development of a theoretical model, research questions, and framing of case studies. These in turn, with a methodological lens of Social Studies of Technology, Symbolic Interactionism, and practice-based perspectives, further guided the initial concepts used in the Grounded Theory for each of the case studies (see summary in Figure 15.1). In answering the research questions, assessing the analysis results, and reviewing previous

models and propositions, this research offered a synthesised theoretical framework and conceptual model for DIY enquiry (Figure 15.2). At each step of this funnelling effect, light was shed on the different dimensions of DIY enquiry. Here I summarise some these contributions and implications.

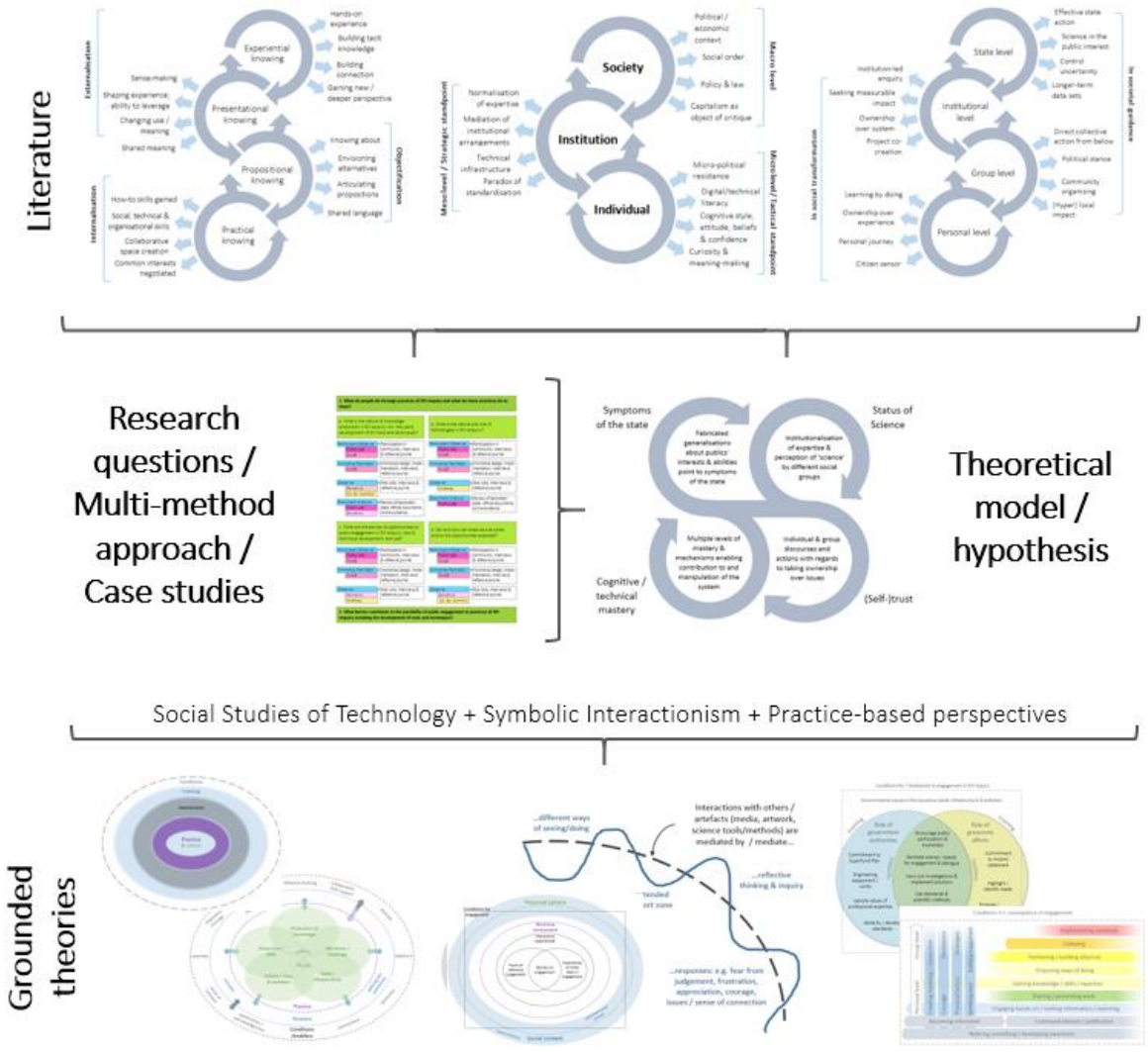

Figure 15.1: Summary of the funnelling approach in this research

Employing different modes of academic enquiry (fieldwork strategy, section 7.4.1, p.155) I disambiguated and refracted the study of DIY: DIY at the individual level, through the lens of researcher as facilitator; DIY as community of practice, through the lens of researcher as participant and community organiser, and DIY as embedded in place, with researcher as observer.

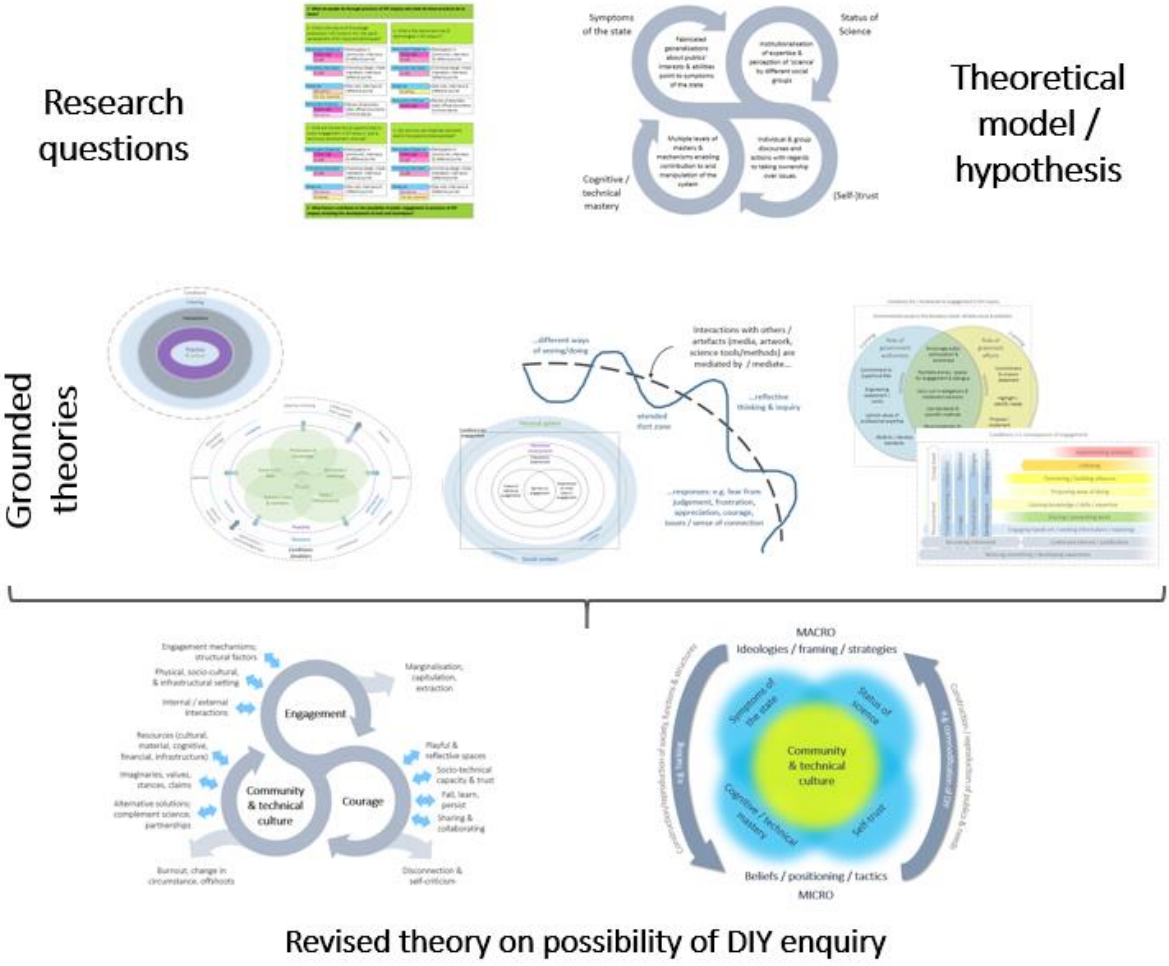

Figure 15.2: Summary of the funnelling approach in this research Part 2

The study of DIY practice at the micro/individual level (Chapter 11) sheds light on how people begin their journey into DIY: what are the initial steps into DIY? How do people become interested? What makes them inquisitive and to dare to try-it-themselves? What are the factors influencing DIY enquiry and the barriers and opportunities to engaging in it? To explore these questions, I designed 'playshops' as adaptable and purposeful spaces for the study of and engagement in DIY enquiry. Through this methodological contribution I found that playfulness facilitates the introduction of new concepts and ideas and thus breaks down barriers to full participation with otherwise 'intimidating' tools or spaces (section 11.3.2, p.253). I found that playfulness also helps to create an engaged setting that extends the comfort zone of enquiry and possibilities of knowledge production; it helps in confronting 'fear' and daring to try different ways of doing and making sense of the world. The nature of production of knowledge and role of technologies become intertwined in the process of

learning through curiosity and wonderment; artefacts not only function as media for self-expression and as arguments/claims about DIY but also help to build DIY competencies and a culture of enquiry (section 11.4, p.255). Playshops as mode and space of enquiry also unveiled that important factors influencing engagement in DIY are courage and self-trust (Figure 11.10, p.267): that is, the trust that individuals develop in their ability to question the world around them, the confidence in their abilities to do/make/take-initiative, and a belief in that what we do actually matters. Additional key factors enabling the possibility of DIY enquiry include a supportive environment and interactions that build continuity. Factors hindering engagement in DIY enquiry at the individual level are feelings of disconnection intertwined with self-criticism and fear of judgement from others. These are summarised in Figure 15.3.

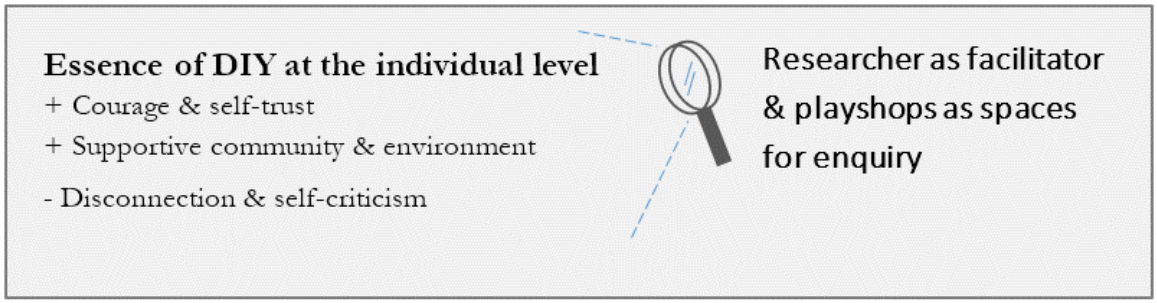

Figure 15.3: Summary of the study of DIY enquiry at the individual level

The study of DIY as active member of a community of practice (Chapter 9), enabled an exploration of how these communities develop: what do people do with DIY at the community level and what does DIY do to them in the context of community? Summarised in Figure 15.4, I found that engagement in DIY at the community level engenders DIY culture and practice characterised by:

- Various actions and roles (boots, tools, outreach) with some members focusing or specialising around topics or tools and others adopting them at different stages of their engagement. The tension in practice was between perceived fragmentation of community functions (e.g. developers vs. community organisers) and the valuing of diversity and emergence in the creation of meanings, competencies, interests, and solutions;
- A wide range of tools and infrastructure that the community builds and draws from. These are embedded in and reassert the values and ethos of the community:

collaboration, openness, learning, empowerment, and diversity. Tools/infrastructure also provide support for interactions and build organisational memory;

- Narratives/meanings, which represent the stories and values of community members; they provide a basis for defining the community identities;
- Production of knowledge as process, which is facilitated by interactions through actions, tools, and narratives. Requires learning and, through (self-)critique, it facilitates/involves reflective thinking about purpose and impact; and
- 'Know-how' as competencies, which is facilitated by openness, supported by infrastructure, interactions, is shaped by and shapes narratives; requires and builds disposition to new ideas and courage to engage in DIY (section 9.6, p.217).

It was also found that issues of inclusion, credibility, and legitimacy are salient tensions between practice and community aspirations (section 9.4.2, p.213). Together these encompass a technical culture representing alternatives to academic/institutional/ professional approaches to research and problem-solving.

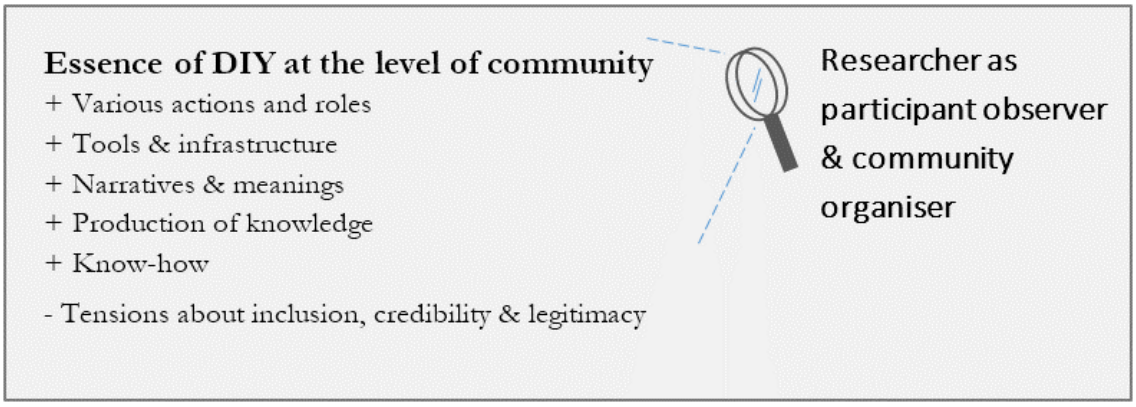

Figure 15.4: Summary of the study of DIY enquiry at the level of community

The study of citizen-initiatives of DIY enquiry embedded in place (Chapter 13) reveals that practice is characterised by inquisitive beginnings and engaged interactions between different stakeholders. 'Place' evokes different (even contested) meanings and DIY in this context emerges as a tactic to find or create common interests that advance particular agendas. Hence, as summarised in Figure 15.5, DIY enquiry is about developing strategies, interacting with others (sharing, being challenged, learning, and building rapport), gaining recognition, seeking partnerships/alliances, proposing strategies, and lobbying for actionable goals (section 13.4, p.310). However, this process, which requires long-term commitment and

experience can lead to burnout and efforts ceasing when support, courage, and/or interest fails.

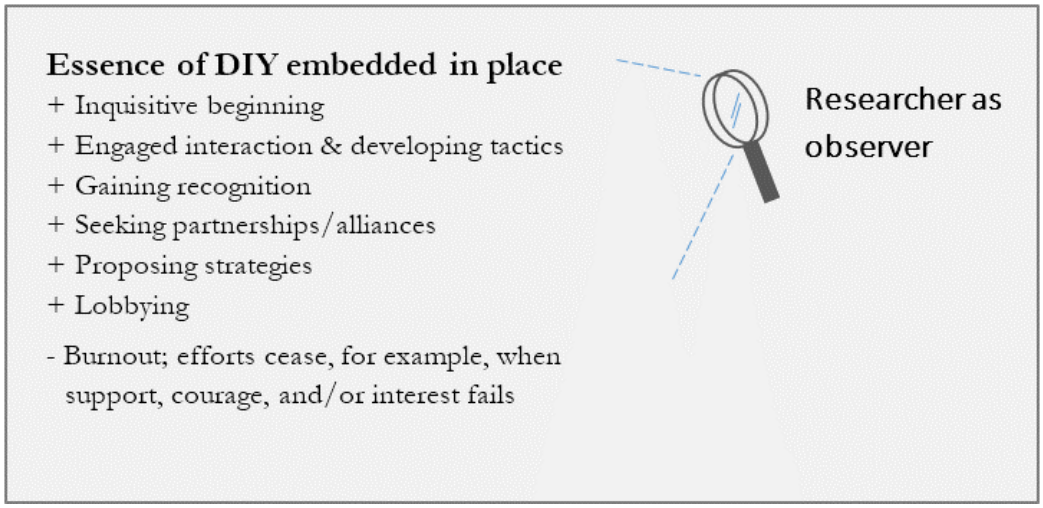

Figure 15.5: Summary of the study of DIY enquiry embedded in place

15.2 Summary of research question findings

The research questions where to understand first, what do people do through practices of DIY enquiry and what do these practices do to them and second, what factors contribute to the possibility of public engagement in practices of DIY enquiry including the development of tools and techniques – with specific focus on the **nature of knowledge production**, the **role of technologies**, and the **barriers and opportunities** to public engagement in DIY enquiry, tool and technique development, and use.

Production of knowledge is both a process and an end goal in DIY enquiry; it is embedded in practice and embodied, symbolically, and materially, in the artefacts the DIYers make and use. Reflective thinking is an integral part of DIY practice and it mediates production of knowledge. Reflective thinking guides production of knowledge as people make sense of and ground their experiences. At the same time, reflective thinking is enabled through dedicated spaces, emotional and physical, perceived as safe, inviting, and fun. Thus, we have learnt that production of knowledge is facilitated by common shared experiences, rhetoric, and practices and requires a sense of ownership, the ability to learn from mistakes, and being disposed to new ideas or possibilities. It specifically benefits from building, making, and publicly sharing objects because, exposure promotes exchange and learning. Building knowledge requires

'experiential learning' but also 'continuity'. Experiential learning occurs through hands on engagement and interactions that build connections and meanings, which in turn begin to build norms and practices. Continuity occurs through sequential or regular events, stability of organisations, or a committed group. Interesting results are that the nature of knowledge changes when DIY enquiry is specifically concerning environmental/social issues; the relationship between knowledge and data becomes central when the concern is to address a pressing problem or reach an actionable goal. In these cases, validity of knowledge, data, and know-how, take centre-stage. Another key finding is that that DIY enquiry and production of knowledge give rise to expertise - as both a skill and an attitude, which draws from and requires recognition and building strategic relations of trust to gain credibility, legitimacy and build rapport.

Technologies play a role in sense-making and facilitating enquiry; they facilitate engagement in action (e.g. monitoring and documentation); they shape practice as their use and design embody (reproduce and perpetuate) values, rhetoric, and culture. Thus, technologies play an important role in creating and shaping 'technical culture' – as symbolisms; as enabling, facilitating, hindering, or sedimenting modes of use, development, operationalisation, expression, etc. (individual or organisational); and as arguments or aspirations (embodied in them). They enable ways of seeing, communicating, questioning, and defying – at times simultaneously – e.g. "to reassert control over a lot of the processes of enquiry that were taken away from me" [2:221]. In these ways, technologies also build and require capacity.

The role of technologies also operates at various levels and can be conceptualised, with more depth, through the theoretical framework. A central question in forging theory at the level of 'symptoms of the state' was 'what is technical DIY in response to'? Empirical evidence led to questioning if all DIY practices are acts of resistance and if all DIY technologies are political by default. I found that not all technologies/techniques are political 'interventions' born out of conflict; there is also intrinsic value. Also, beliefs, manifested as values/ethos/manifestos do shape (drive) real social and political change. Technologies and technologists/facilitators/DIYers equally perform 'expert power' through their symbolisms and attention needs to be given to whose symbolisms and beliefs are the 'loudest'? What stance/power do they hold? What are the hidden interests/agendas of DIY community organisations and what do we promise/assume about technologies and DIY culture?

The 'status of science', at the institutional (meso) level, focuses on the symbolism of expertise and its effects on institutional arrangements and leveraging of power. Thus, it impacts design, access, and conception and framing of technologies and supporting infrastructure and support mechanisms. The literature suggests that tools (e.g. sensing devices) can change the nature of 'public' because they affect practices and relationships, altering the means by which concerned citizens can participate in public debates. My research provides insights into these symbolism of expertise. For example, how stance (as e.g. position of power) shapes the way technologies are framed: on one hand authorities judge DIY tools, techniques, and the citizen data produced against traditional standards; at the same time, DIYers leverage and align their methods and data with traditional standards to gain policy action as part of advocacy efforts. This is linked to the question 'why is that most references to DIY seem to evoke 'technologists', 'tinkerers', etc. rather that 'scientists'? It does seem that 'Science' as symbolic belief of 'expert power' does shape how the practice of enquiry unfolds: in particular in cases where technologies and data are framed and leveraged to align with scientific conceptions to gain a stronghold and credibility (DIY as a means) as opposed to those cases mainly developing/proving a technology/technique (an end).

'Self-trust' and 'cognitive and technical mastery' operate at the individual (micro) level. Here the literature suggests that in order for people to participate, 'notionally accessible' tools need to become actually available and people need to feel confident using them. My research shows that 'notional accessibility' and 'confidence-in-use' require that both the technologies and the DIYers are transformed; 'making' transforms DIYer and artefact as a continuous process that creates new frames of reference and simultaneously develops, draws from, and requires literacy and competencies (social and technical). Linked to this, a central, yet unspoken question remains: can everyone engage in DIY – or – is DIY for everyone? The research suggests that in general terms, there are several requirements for engagement (cognitive, technical, social, etc.), which themselves require resources, time, commitment, access to spaces, knowledge, (peer) support, etc. In addition, engagement requires a perceived need to drive it forward and a particular attitude of daring. However, these are acquired/gained in various (often unexpected) forms, as DIY does not follow conventions.

Barriers and opportunities to engagement in DIY enquiry can be summarised in terms of level, as personal and organisational, and social. At the personal level, barriers and opportunities are manifest in attitude and capacity. Enablers here include will and ability to take risk or initiative, patience, persistence, vision, accepting failure (or redefining it), ability

to reveal oneself and letting go, dexterity, and competence. Barriers include inhibitions and experiencing lack of connection. Barriers and opportunities are also manifest in terms of resources: access to mentors, peer/group support and guidance, on-boarding, access to knowledge and the language/lexicon to make connections, and facilitates the process of making sense of the world, and (co)developing strategies. Framing can also act as a barrier and opportunity. This includes how DIY is perceived internally and externally – what value is placed on DIY engaging communities, network collaboration, and individual and grassroots community efforts, how are these judged, against what and by whom? At the organisational level barriers and opportunities are manifest through culture and as practices of inclusion are acknowledged, promoted, and embedded. Opportunities arise when organisations acknowledge the different speeds and trajectories of their activities and actions (e.g. community engagement vs. software development) because it recognises that each of these draws from different knowledges and requires different modes of enquiry. Another opportunity arises when there is active documentation and systematisation of practices and evidence – is creates shareable knowledge, common lexicon, and shared meaning, and it provides legitimacy and validity. Culture and practices can turn to be hindering barriers when they become sedimented and begin to take for granted or exclude (new) practices. Another external barrier is when organisations' nature as emergent and flexible is dismiss as lack of focus by funders or other institutions/agencies in power. Institutional requirements for grassroots organisations are often hindering burdens. However, organisations and individuals have developed strategies to match those requirements to gain validity and build partnerships in order to achieve actionable goals. Barriers and opportunities are manifest at the social level as socio-economic and cultural behaviour, which are broader and extend beyond DIYers and organisations. Individuals and groups have created purposeful reflective spaces to think critically about privilege, social construction of ideas and ideal, and how to avoid perpetuating power relations.

15.3 Theoretical contributions

This thesis research contributes a theoretical framework to understand the factors that contribute to the possibility of DIY enquiry – the challenges, opportunities, and implications to conception and practice. The model is a new conceptual mix that draws from models providing micro and macro lenses into DIY from perspectives on knowledge, technology, and engagement. The examination of three in-depth case studies exploring the nature of the

production of knowledge and the role of technologies provides empirical evidence for how practices of DIY enquiry unfold and are shaped at the individual, community, and place contexts. Some of the important aspects of this work are summarised in Table 15.1.

This research also adds to the debate on democratisation of science and technology. Technologies have been traditionally placed at the centre of analysis. The consequence is that technology itself has become taken for granted. This research revealed that it is the 'technical culture' (practices, interactions, interpretive frameworks, etc.), which technologies are foregrounding (and therefore shadowing) that is important. From a constructivist and structuralist standpoint, the role of DIY technologies sits within an iterative shaping between technologies and culture, where people, as individuals or groups shape and remake technologies with their aspirations, assumptions, social values, and political agendas and where these people are shaped by those meanings, values, and politics embedded in artefacts. Therefore, attention needs to be given to the new forms of association, the disruptive, and provocative interactions that come about through the use, development, and reappropriation of artefacts that deserve our attention. It is these that represent the potentiality of DIY enquiry. Part of our technical culture includes how we frame and study technologies, which in turn shapes design and strategies that support them.

In addition, current critiques of technical DIY (within the debate on democratisation of science and technology) revolve around issues of inequality (e.g. that it is white-male dominated and/or is commodified by corporations). However, while these critiques reveal the trends hidden behind some dominant practices, they also mask the diversity in grassroots/DIY initiatives – the knowledge, know-how, tools, and new forms of meanings and associations they produce. The theoretical framework developed in this study elucidates the issues and opportunities that arise at different scales of DIY enquiry and their implications.

Table 15.1: Contributions to research

Contributions of this research	Supported by
An increased depth & breath of Public Engagement, in particular, understanding processes of production of knowledge, tools, and technical culture	The development of conceptual models for the study of DIY in the topics of knowledge (Figure 2.1 p.50), technology (Figure 3.1, p.74), and engagement (Figure 4.3 p.95) and their application in the analysis of the case studies as initial guiding concepts and in preliminary conceptual models (sections 9.1, 11.1, & 13.1)
A better understanding the barriers and opportunities to DIY enquiry can guide the creation of interactions, spaces, and even mechanisms that spark meaningful engagement in enquiry	Advancing literature on spaces for experiential learning (section 2.2.3) and giving empirical evidence, in particular through the modelling of engagement, enablers, and community in playshops (Figure 11.10, p.267); all cases deal with this
Highlighting that attention needs to be given to grassroots initiatives because these represent specific kinds of local knowledge, issues, and politics; different frames/standpoints on local issues; potential alternatives to traditional approaches; responses or critiques to systemic pressures; and can provide an opportunity to pinpoint and revise existing norms and regulations	Confirming literature supporting these claims (section 1.3); case studies demonstrating: different ways of knowing and doing (Ch. 9, 11, & 13); development of grassroots techniques & tools for environmental monitoring (Ch. 9 & 13); development of strategies for achieving actionable goals (Ch.13); framework for the analysis of citizen-led initiatives as responses to broader societal issues (sections 5.2 and 5.3)
A better understanding of different standpoints of DIY sheds light on ways to leverage production of knowledge between professional/institutional science and civil society	Thick description on role of community organisations in raising awareness & promoting participation (section 13.2.2); use and production of DIY tools (section 9.3); modes of identifying needs (13.2.4); providing, framing, & leveraging proof (section 13.3); and the nature of lobbying and advocacy (section 13.4)
A constructivist-interactionist approach as methodological orientation enables a more holistic approach to the complex study of DIY enquiry at different scales	Approach informing the modelling of conceptual models for the study of DIY enquiry (Figures 2.1 p.50, 3.1 p.73, & 4.3 p.95); approach guiding considerations for theoretical framework (Tables 3.1 p.59 & 6.2 p.134) and examination of issues of inclusion and exclusion in DIY practice at the societal macro-level and individual micro-level.

Illuminating the micro-, meso-, and macro- practices of DIY enquiry sheds light on the democratic potential of public engagement in science and technology. The revised theoretical model (section 14.3 p.337) presents guides to identify challenges to the practices of DIY enquiry (Tables 14.1-14.4). This research has also given evidence for exclusionary

mechanisms that hinder DIY practice (e.g. how standards are used to subject citizen data (and the efforts associated with it) to specifications of validity, liability, and reliability (section 13.3.1)) and exclusionary practices/circumstances embedded within DIY practice (e.g. "Every time you add a step, every time you add a requirement, every time you add knowledge that must be implicit or that people must have before they can participate, you are narrowing the field of people who can participate" [1:61] (p.199)). Understanding these exclusionary mechanisms helps to identify wider issues of public engagement – namely, the formulation, perpetuation, and access to hegemonic ideologies through the iterative 'social construction of publics' and 'human construction/reproduction of society'. It also helps to find ways to fulfil the potential offered by the social and technological trends of our time.

15.4 Implications of the study and future research

The findings, conceptual models, and theoretical framework could be of interest to researchers of Public Engagement in science and citizen science, in particular those promoting the democratisation of science. Following in the steps of researchers like Jack Stilgoe and Gwen Ottinger, this research can also be of use to improve the competencies and literacy of scientists, engineers, and researchers in general, who seek to work with community organisers. For example, the research highlights that a community of DIY practice is not just a set of 'instructions' or 'documentation' for extraction – but a doorway to a living, human knowledge base. Similarly, funders can use this research to gain a better understanding of the way grassroots work unfolds and how its emergent nature is its strength and which is often compromised when moulded to fit the requirements of funding schemes. This work is also intended to directly benefit the groups involved in the research by providing empirical baselines, critical analysis of practices, and frameworks that can guide practice and nurture internal/external relationships.

As outlined in Chapter 7, the level of theory forged in each case study is specific (substantive) to this particular research topic, context and settings investigated. To forge formal theory, wider theoretical sampling in a wide range of areas (multiple fields of study) and from multiple sources of evidence need be carried out. Research on another community of practice, with another set of playshop participants in another location, and citizen-led research initiatives in another locality could shed light on additional aspects of DIY enquiry

and reveal assumptions about the substantive theories forged. This could also shed light on the 'blank' and 'blind' spots of researchers and of local ways of knowing.

This research could prove most valuable at the intersection between institutional and grassroots science. It could provide the building blocks to inform a collaborative and purposeful partnership between government and community organisations. For example, furthering research on practice-based perspectives, a framework could be developed to guide a pilot study to develop mechanisms for mutual learning, practice sharing, research co-design, and tool development between state actors (e.g. environmental protection agencies) and community organisers. Community organisers could shadow the work of the state actors, with access to their data and public plans so that they can develop complementary or alternative approaches, solutions, tools, etc.

Playshops are a way to engage in playful and empathic mutual learning through exchanges that enrich people's own experiences by sharing different ways of knowing and doing. Hence, the spaces for DIY enquiry created through the playshops can also be of interest to those seeking to design public engagement activities that halt power relations and unhelpful hierarchies in research. The playshops also offer a wealth of opportunities for future research and practice. By adapting the design and facilitation of the playshops, the link between the field of 'art therapy' and 'emergent enquiry' could be widely explored applied to e.g. environmental sensing, the link between 'wellbeing' and environmental conservation, introduction to DIY biology, etc. For example, research could explore if the playshop approach to emergent enquiry would impact modes of public engagement and production of knowledge in monitoring or conservation: what would it be like if citizen researchers are able to develop their own modes of enquiry, frame their own problems, are encouraged to give their experiences material/artistic representation as a way to connects self, the environment, and issues, and thereby explore alternative framings/solutions to local issues?

The theoretical and conceptual framework produced can guide practice and shape structures supporting researchers, educators/facilitators, and evaluators of Public Engagement. For example, the opportunity also arises in using the revised theoretical framework for the evaluation of science events: their facilitation, their impacts, and sustainability, as is currently being done for the EU project 'Do It Together science'.

* * *

To conclude, I believe that the power of DIY lies in its potential – as a way to (re)gain an appreciation of each other's work, approaches, interpretations, reasons for doing what we do, which is lost when we stop interacting, when our standpoints stop meeting, and when we treat each other as means to an end. DIY enquiry has the potential – through dedicated spaces, symbolic artefacts, and cultures – to purposefully connect system and lifeworld. Through iterative reflections, learning, experimentation, (re)formulation of ideas, and disagreements we can create interactions and discourses that keep us and our systems in check; we can repair the severed links and meanings that create the sociotechnical structures that sustain us and our social heritage.

DIY enquiry places great value in collaborative efforts of exploration, investigation, and problem-solving. It not only invites us to question the state of things and promotes the tools and techniques to do so – it also invites us to dare and to embrace uncertainty and vulnerability as the birthplace of innovation, creativity, and change.

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Appendix A: Interview guides

A.1 Community of DIY practice

- How did involvement with Public Lab start?
- Key words to describe Public Lab - community, activities, etc.
- What is the extent of possibility with Public Lab's activities (what is and is not possible?)
- Barriers to entry into the community? (challenges to engagement / what conditions need to be in place in order to engage?)
- External perception of Public Lab's work, community, etc.
- Who is present (at this Barnraising) and who is missing
- How/does the work that Public Lab do link to broader society? Is it relevant to more than just the community?
- At individual level what attracts people to engage with, either the tools or the community, etc. in Public Lab
- How/Has engagement with Public Lab tools/community changed you? (impact of engagement)
- Role of creativity in Public Lab
- Considering the name of the organisation, what does 'Public', 'Technology', and 'Science' mean to you?
- What does 'scientific research' mean to you?
- What is the nature of knowledge produced in Public Lab - how does it compare to the 'data' produced? What does it represent?
- What role to the tools play in Public Lab?

A.2 Public engagement in DIY enquiry through playshops

The *Explorer of the World playshops* were based on the *Exploring Borders through Art* playshop series in terms of methodology for engagement in DIY and in terms of building the Citizens without Borders community, which then took interest in the Explorer of the World playshops. As the facilitator of the DIY science workshops understood the value and influence of the Exploring Borders through Art playshops and its interrelatedness with the Explorer of the World playshops, she created an additional set of questions that would help gain a deeper insight into the more complex relations, creativity and learning involved in these playshops. The questions used in the interviews with playshop participants revolved around the following themes and questions:

- Influence of Exploring Borders through Art playshops on engagement in Explorer of the World playshops
- Describe in your own terms what the Explorer of the World playshops were about
- Were you inspired to ask questions or be curious as a result of the playshops?
- Relation of playshops to themes or disciplines
- New learning as a result of participating in playshops (question asked individually for each of the 6 playshops in the series)
- Perceived changes in personal life as a result of engagement in playshops
- If attended 1st round of Explorer of the World playshops in year 1, then asked how experience compares with engagement in Explorer of the World playshops in year 2.

- Was there anything that we did not do in the playshops that would have been interesting to do or that we should try for the next series of playshops?
- The role of artefacts during playshops (e.g. mapping equipment or artwork as medium for self-expression)
- The role of the facilitator in the playshops
- Suggested changes to playshops (if were to do them again, what would you change?)
- Comment on anything else that was not talked about during the interview

Engaging in these kinds of conversations incited participants on several occasions to ask their own very engaging, thoughtful and thought-provoking questions to the facilitator. For example:

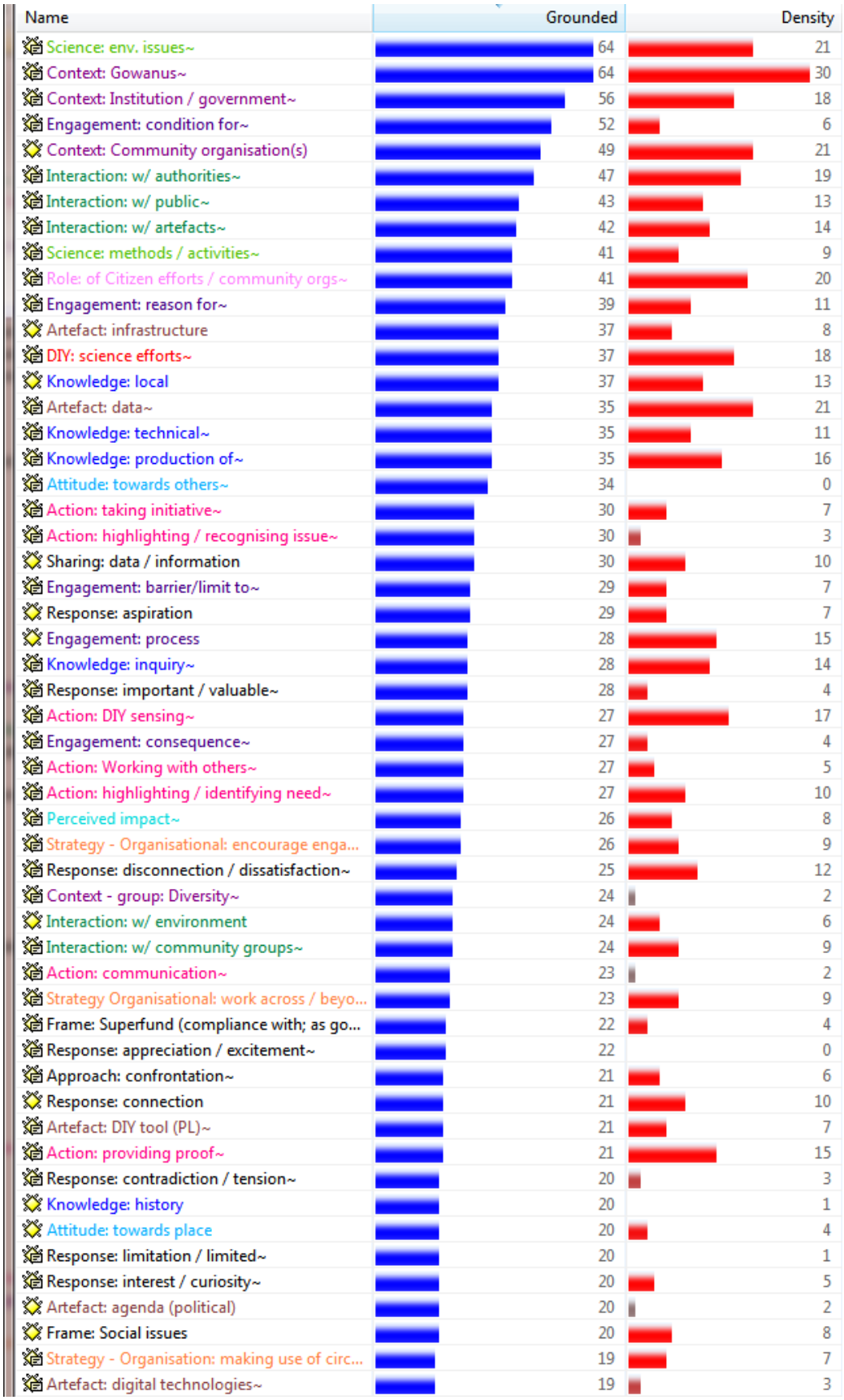
- Why do you organise these events?
- What are you trying to achieve?
- What motivates you?
- Did you feel like you gained something from organising these playshops?
- What do you feel is most valuable?
- Did you ever feel frustration of any sort?
- Do you want this to grow or make it bigger and have more influence?
- Do you want to make it more accessible to more people? Why?

A.3 Place-based citizen-led initiatives of DIY enquiry

- Gowanus Canal stakeholders: perception of who these are
- Environmental monitoring techniques/approaches: objectives, instrumentation (types, development, use, impact of use), monitoring plan (collection/sampling methods, parameters, testing, types of data), strategy (timings, frequency, locations, etc.)
- Environmental monitoring data: quality/validation, management, interpretation, publication, sharing, dissipation, public documentation, etc.
- (Perceived and evidenced) Impact of environmental monitoring & related efforts: on e.g.
    - Societal scale: conservation efforts, public engagement/perception, education, business/private sector, public sector, 3rd sector, funding, policy, etc.
    - Individual scale: innovation/tool development, monitoring participants (engineers, public, students), local residents
- Public engagement:
    - Instigated engagement: objectives, target groups, strategy (outreach, recruitment, events), type of engagement, initial stages of involvement, length of involvement, outcomes of engagement
    - Publicly initiated: objectives, type of engagement, initial stages of involvement, length of involvement, outcomes of engagement, target audience(s)
- Public perception:
    - interviewee's and/or organisation's and work as perceived by the public
    - on the Gowanus Canal: health, efforts to restore it, etc.
- Successes of group/individual's work: in strategies, campaigns, results, outreach, partnerships, etc.
    - Drivers of their work
- Challenges of group/individual's work: methods, results/impact, personal life, challenges their work pose, etc.
    - Barriers to their work

A.4 ATLAS.ti code manager example

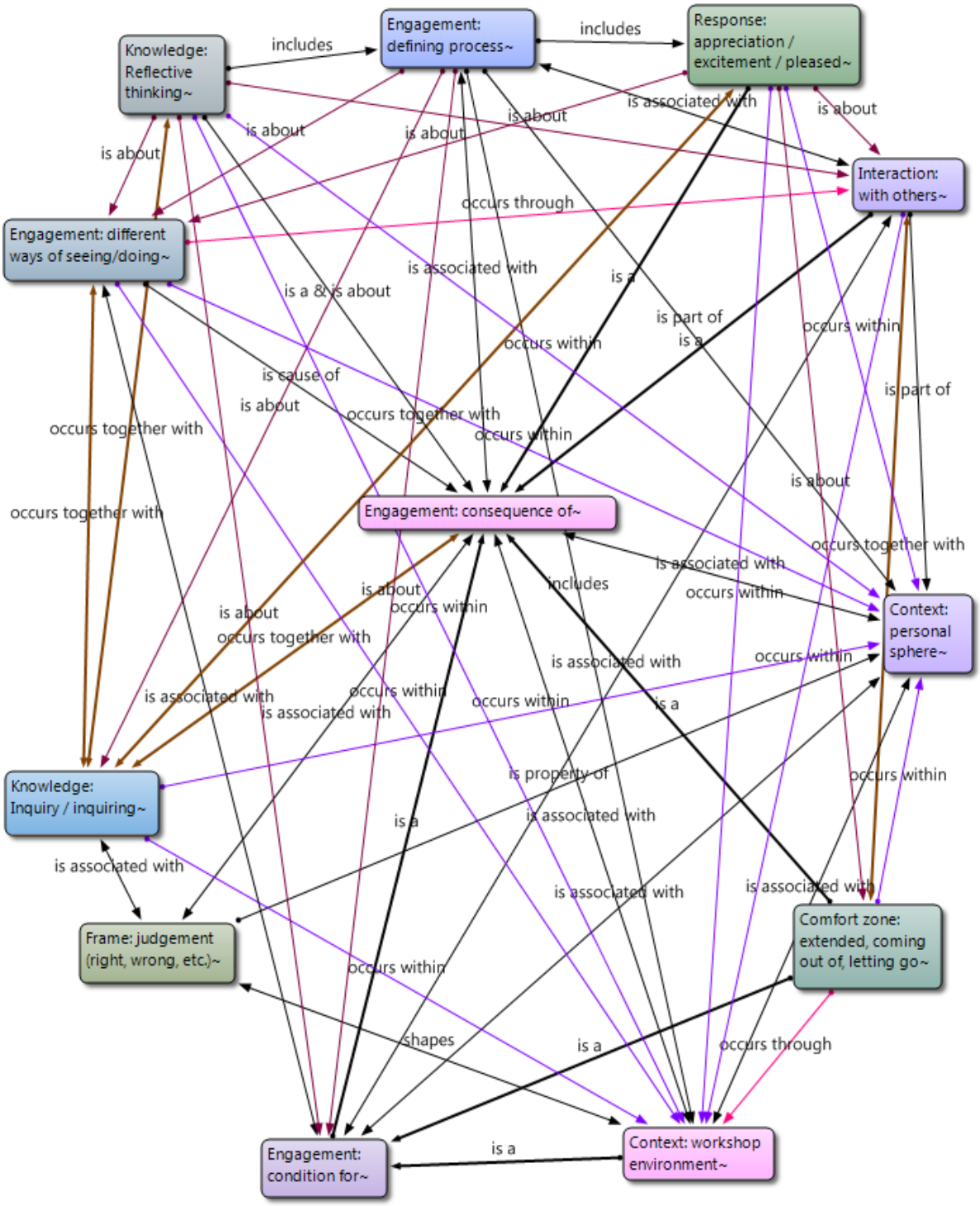
Code list for Place-based citizen-led initiatives of DIY enquiry case study organised for groundedness.



Name	Grounded	Density
Science: env. issues~	64	21
Context: Gowanus~	64	30
Context: Institution / government~	56	18
Engagement: condition for~	52	6
Context: Community organisation(s)	49	21
Interaction: w/ authorities~	47	19
Interaction: w/ public~	43	13
Interaction: w/ artefacts~	42	14
Science: methods / activities~	41	9
Role: of Citizen efforts / community orgs~	41	20
Engagement: reason for~	39	11
Artefact: infrastructure	37	8
DIY: science efforts~	37	18
Knowledge: local	37	13
Artefact: data~	35	21
Knowledge: technical~	35	11
Knowledge: production of~	35	16
Attitude: towards others~	34	0
Action: taking initiative~	30	7
Action: highlighting / recognising issue~	30	3
Sharing: data / information	30	10
Engagement: barrier/limit to~	29	7
Response: aspiration	29	7
Engagement: process	28	15
Knowledge: inquiry~	28	14
Response: important / valuable~	28	4
Action: DIY sensing~	27	17
Engagement: consequence~	27	4
Action: Working with others~	27	5
Action: highlighting / identifying need~	27	10
Perceived impact~	26	8
Strategy - Organisational: encourage enga...	26	9
Response: disconnection / dissatisfaction~	25	12
Context - group: Diversity~	24	2
Interaction: w/ environment	24	6
Interaction: w/ community groups~	24	9
Action: communication~	23	2
Strategy Organisational: work across / beyo...	23	9
Frame: Superfund (compliance with; as go...	22	4
Response: appreciation / excitement~	22	0
Approach: confrontation~	21	6
Response: connection	21	10
Artefact: DIY tool (PL)~	21	7
Action: providing proof~	21	15
Response: contradiction / tension~	20	3
Knowledge: history	20	1
Attitude: towards place	20	4
Response: limitation / limited~	20	1
Response: interest / curiosity~	20	5
Artefact: agenda (political)	20	2
Frame: Social issues	20	8
Strategy - Organisation: making use of circ...	19	7
Artefact: digital technologies~	19	3

A.5 Example of ATLAS.ti network view used for theoretical integration

Example from DIY enquiry through playshops; main category placed in centre and relation to other codes is iteratively established through generative questioning



Appendix B

B.1 Code list for Community of DIY practice case study

Access: issues of
Action: activism
Action: Advocacy
Action: DIY sensing
Action: documentation
Action: exploring
Action: Holding polluters accountable
Action: identifying need
Action: investigating
Action: monitoring
Action: replicating
Action: responsiveness
Action: restoring env
Action: seeking understanding
Action: Visioning / imagination
Approach: participatory
Artefact: Data
Artefact: Event / Barnraising
Artefact: Pollution
BEGINNING OF PUBLIC LAB
Communication: creating the narrative of PL
Communication: difficulty in explaining what PL does
Communication: forms of communication
Communication: issues of communication
Communication: ways of telling the story / strategies
Community: allies and extending community
Community: commitment to
Community: community <-> individual relationship
Community: critique of
Community: culture and practices example
Community: demarcation of community
Community: diversity and complexity
Community: growth of the community
Community: infrastructure
Community: interconnectedness of actions / roles
Community: issue of importance to the
Community: issues being addressed by the
Community: issues faced by the
Community: issues of flexibility and openness
Community: outreach
Community: parts of the community
Community: responsibility of
Community: shaping community
Community: strategies for building practices
Community: sustainability of community
Community: taking ownership/responsibility
Community: value(s) held
Community: wishes / aspirations for the community
Context: Environmental issues
Context: issues of power
Context: Local
Context: Social issues
Context: Social justice
Context: Workshop
Creativity
DIY: defining the DIYer
DIY: method
DIY: non-tech
DIY: tools
Engagement: (causing) initiative-taking
Engagement: attitude towards
Engagement: barriers to engagement
Engagement: conceptualising agency
Engagement: connection / relevance to personal work, etc.
Engagement: consequences of
Engagement: defining process
Engagement: discussion about
Engagement: education
Engagement: empowering actions
Engagement: Enjoyment
Engagement: equality
Engagement: face-to-face / offline
Engagement: initial process or steps
Engagement: length of engagement
Engagement: mode of engagement
Engagement: motivation for
Engagement: online
Engagement: pattern of participation
Engagement: promoting
Engagement: proposing alternative

Engagement: providing support / being supportive
Engagement: questioning engagement
Engagement: reasons/conditions for participation
Engagement: space for
Engagement: strategies for engagement
Engagement: Taking initiative/action
Ethics
Exclusion: instances of / conditions for
Expertise: pointing out informal
Expertise: questioning expertise
Goal: address issue/problem
Government and institutions: expectations from
Government and institutions: realising impact of PL
Impact: documenting impact
Impact: on attitude
Inclusion: consequences of
Inclusion: feeling included
Inclusion: pointing to issues of
Inclusion: tactics or strategies for
Interaction: w/ artefacts
Interaction: w/ environment
Interviewee background
Knowledge: issues of
Knowledge: local
Knowledge: production of knowledge
Knowledge: questioning what science/technology is
Knowledge: Reflective thinking
Learning: being disposed to new ideas - it clicks
Learning: frustration in learning curve
Learning: importance of failure
Learning: lessons learnt
Learning: ownership over learning / something would like to learn about
Learning: realisation of how PL has developed
Learning: working things out
Local <-> Global connection
Making
Personal aim
Playfulness: Issues of
Playfulness: playful comment or humour
Practice: innovation in - approach, tools, arrangement
Practice: limits to participation
Practice: potential of
Practice: providing granularity
Proof of concept
Research: doing / issues of
Research: role of researcher
Response: "this is powerful"
Response: acceptance / acknowledgement
Response: admiration
Response: appreciation
Response: aspiration
Response: awareness
Response: caution
Response: challenge
Response: connection to larger context
Response: connection to the real world
Response: courage
Response: create impact
Response: creating connection with people
Response: critique
Response: curiosity
Response: different ways of seeing / doing
Response: disconnection
Response: disappointment
Response: excitement
Response: feeling proud
Response: feeling supported
Response: frustration
Response: fun
Response: important / of importance
Response: meaningful
Response: openness
Response: respect
Response: sense of purpose
Response: unproblematic / smooth
Response: welcoming
Scalability
Science: avoiding patronising
Science: comparison to traditional
Science: formal/traditional science
Science: grassroots
Science: issues communicating science
Science: issues of credibility/legitimacy
Science: popularise it
Science: rigour in method
Science: Scientists' interaction with the public
Science: subjectivity (in procedure, framing, etc.)
Sharing: a vision
Sharing: data / techniques / knowledge
Sharing: giving credit or attribution
Sharing: meaning and values
Sharing: not sharing or attributing

Sharing: ownership
Sharing: the importance of sharing
Success story
Technologies: challenge in development
Technologies: consequences of design
Technologies: design process
Technologies: design tactics / strategies
Technologies: development of software and hardware
Technologies: differentiating between tools and techniques
Technologies: digital
Technologies: discussion about
Technologies: interplay bwtn tools & issues
Technologies: issues of
Technologies: Open source
Technologies: physical objects / materiality
Technologies: problem solving
Technologies: role of
Technologies: technologists (and their role)
Technologies: use of software and hardware
TENSION
TRAJECTORY
USE OF DISCIPLINARY JARGON
Working with people: challenges
Working with people: collaborative work
Working with people: creating opportunities for people
Working with people: interactions between actors
Working with people: interconnectedness, complexity, parts of the whole
Working with people: partnerships

B.2 Full image of roles/perspectives on the DIY culture/movement

Roles/perspectives on the DIY culture/movement: the 'doers', the 'supporters', the 'hype', the 'sceptics', the 'disbelievers', those 'who do not know' about the DIY movement and the 'in between people'

Appendix C

C.1 Code list for Public engagement in DIY enquiry through playshops case study

Activity: Exploration as activity or experience
Activity: Making
Comfort zone: curiosity
Comfort zone: discussion about
Comfort zone: element of surprise
Comfort zone: extended, coming out of, letting go
Comfort zone: staying within/holding on to
Context: comparing Art & EoW playshops
Context: group
Context: not ordinary/everyday
Context: personal sphere
Context: relevant to everyday life
Context: society
Context: workshop environment
Engagement: "embracing vulnerability"
Engagement: barrier to
Engagement: condition for
Engagement: consequence of
Engagement: defining process
Engagement: different ways of seeing/doing
Engagement: DIY - making do
Engagement: initial steps/reactions
Engagement: learning
Engagement: mode/pattern
Engagement: Play & playfulness
Engagement: reason for
Frame: childhood
Frame: expectation
Frame: judgement (right, wrong, etc.)
Frame: social standard
Interaction: with artefacts
Interaction: with others
Knowledge: discussing enquiry
Knowledge: Enquiry / inquiring
Knowledge: personal meaning-making
Knowledge: Reflective thinking
Medium: artefact(s)/instruments
Medium: Artistic expression
Medium: senses
Response: ambivalence
Response: appreciation / excitement / pleased
Response: aspiration
Response: challenge
Response: courage / self-trust
Response: critique
Response: frustration
Response: importance
Response: initiative taking
Response: inspiration
Response: issues/sense of connection
Response: joy
Response: proud
Response: relaxed
Response: Sense of purpose
Response: something as meaningful
Science: conceptions
Science: environmental issues
Science: science activities
Sharing: experience
Sharing: meaning

Appendix D

D.1 Code list for Place-based citizen initiatives of DIY practice case study

Action Activism
Action: acting ethically
Action: agreement / consensus
Action: assessment of risk /exercising caution
Action: being challenged
Action: being visible / available
Action: challenging status quo
Action: communication
Action: competition / rivalry
Action: critique
Action: debating / dialogue
Action: delegation of responsibility
Action: designing / planning
Action: discovery
Action: dismissal
Action: displacement
Action: DIY sensing
Action: Education
Action: Entertainment / recreation
Action: Exercising Authority
Action: Exploration
Action: highlighting / identifying need
Action: highlighting / recognising issue
Action: identifying opportunity
Action: imagining / visioning
Action: lobbying / advocacy
Action: loss of trust
Action: making
Action: NONE
Action: play / playing
Action: presenting solution
Action: providing proof
Action: questioning
Action: seeking collaboration / cooperation
Action: seeking understanding
Action: taking initiative
Action: Working with others
Approach: conciliatory
Approach: confrontation
Artefact: agenda (political)
Artefact: Art / artwork
Artefact: Credibility
Artefact: data
Artefact: digital technologies
Artefact: DIY tool (PL)
Artefact: engagement activity
Artefact: historic
Artefact: infrastructure
Artefact: narrative / storytelling
Artefact: Policy
Artefact: pollution (incl. visual)
Artefact: Science expertise
Artefact: standard / rule
Attitude: towards artefacts
Attitude: towards others
Attitude: towards place
Context - group: Diversity
Context - Organisational: struggle
Context - personal: anecdote
Context - personal: background
Context - personal: struggle
Context: Community organisation(s)
Context: Development
Context: Gowanus
Context: Institution / government
DIY: Citizen data
DIY: culture
DIY: for its own sake
DIY: granularity
DIY: method
DIY: science efforts
Engagement: availability / free time
Engagement: barrier/limit to
Engagement: condition for
Engagement: consequence
Engagement: creation of place
Engagement: empowerment
Engagement: growth
Engagement: learning
Engagement: process
Engagement: reason for
Frame: (lack of) expertise
Frame: childhood
Frame: conflict
Frame: Emergence
Frame: Fitting the system
Frame: Funding
Frame: individual vs group
Frame: pop culture
Frame: regulation
Frame: Social issues
Frame: Superfund (compliance with; as goal/purpose)
Goal/purpose: mismatch with/in

Goal/purpose: promote participation
Goal/purpose: raising awareness
Goal/purpose: see what's there
Interaction: w/ academic authorities
Interaction: w/ artefacts
Interaction: w/ authorities
Interaction: w/ community groups
Interaction: w/ environment
Interaction: w/ media
Interaction: w/ public
Knowledge: belief
Knowledge: history
Knowledge: enquiry
Knowledge: local
Knowledge: meaning - creating
Knowledge: misinformation
Knowledge: production of
Knowledge: technical
Ownership
Perceived impact
Response: acceptance / validation
Response: ambivalence
Response: appreciation / excitement
Response: aspiration
Response: beneficial / useful
Response: change of mind
Response: commitment / persistence
Response: complementarity / compatibility
Response: complexity
Response: connection
Response: continuity
Response: contradiction / tension
Response: courage
Response: dangerous
Response: defending
Response: determination / forthcoming
Response: disconnection / dissatisfaction
Response: drive / motivation
Response: easy / simple
Response: expectation
Response: fun / pleasure / whimsical
Response: horrible / unacceptable
Response: humility
Response: humour (using)
Response: important / valuable
Response: influence
Response: interest / curiosity
Response: limitation / limited
Response: Not far-fetched
Response: not much there
Response: Not previously known / available
Response: not relevant (directly)
Response: not valid
Response: perceived apathy
Response: perceived ignorance
Response: realistic
Response: relevance
Response: respect
Response: Ridiculing
Response: rigidity
Response: riled up / concerned
Response: scepticism
Response: tired
Response: training required
Response: uncertainty
Role: of Citizen efforts / community orgs
Role: of facilitator
Role: of Government
Role: Technologies
Science: deduction
Science: discussion
Science: env. issues
Science: methods / activities
Sharing: data / information
Strategy - Organisation: making use of circumstances
Strategy - Organisational: encourage engagement
Strategy - Personal: building rapport
Strategy - Personal: reaching out / encouraging engagement
Strategy - Personal: working with / in the name of others
Strategy Organisational: work across / beyond differences
Technology: economic issues
Technology: innovation
Technology: technical / data issues
Value: agency
Value: sharing

Appendix E

E.1 Perspectives from Action Research

This section directly extends Figure 2.2 (p.50).
Knowledge production approaches in Action Research (AR) call for reflexivity. Kemmis (2010) argues that the goals of action research are 'understanding', 'acting', and 'relating'. That is, to explore new ways of doing things, new ways of thinking, and new *ways of relating to one another and to the world* in the interest of finding those new ways that are more likely to be for the good of each person and the good of humankind, and more likely to help us live sustainably (p.425). Action research specifically points to developing situated understanding that is not only done for the sake of knowledge but for the sake of what happens as a consequence of our actions. It is about creating models of democratic dialogue and practical deliberation, and thus to offer people other ways of relating to one another. Action research seeks to bring together action and reflection, theory and practice, in participation with others, in the pursuit of practical solutions to issues of pressing concern to people, and more generally the flourishing of individual persons and their communities (Reason and Bradbury, 2001, p.1).

A closer look at DIY and ways of knowing. People across the world engage in DIY for a multiplicity of reasons (Wehr, 2012). Interests and motivations include conscious and politicised responses to a complex and fast-moving world, the pride of having a job well done, and needing/wanting to save money. Most importantly, it provides a means to give representation to or voice concerns, express oneself, take ownership over issues, and take action. The essence of DIY is one of self-: self-learning, self-drive, and being self-directed and self-reliant (as a welcome or unwelcome necessity). Taking ownership is a powerful experience and it is often linked to a realisation that makes us question what happens around us: Doing-it-ourselves incites us to figure out things by ourselves, to do things that have not been done before (by us or others), and to challenge who can (or should) do it and how. For example, who should take charge of environmental monitoring and who can hold polluters accountable? 'Designing-It-Yourself' empowers individuals with the means and tools to prototype new ways of thinking and living, at any scale (Irani, 2008, p. 10). Conceptualised in this way, an understanding of practices of DIY acknowledges and focuses on people's capacity to act and respond as a process of sense-making and inquiry – in people's own terms.

This sense of ownership over the process of inquiry and production of knowledge can be better understood through the model of ways of knowing in action research. Heron and Reason (2008) propose an extended epistemology of experiential, presentational, propositional, and practical ways of knowing embedded in cycles of action and reflection (p.366). Ways of knowing are the everyday concerns that shape and nurture people's processes knowledge production through interactions, inquiry, and sense-making. This extended epistemology is useful in (re)orienting research a strong emphasis on what Reed (1995) called the 'social world of the investigator' (social theories) to an intersection with 'the social world of the actors' ('local' meanings and actions). That is, moving from asking "does this piece of theory correctly describe society's workings?" to "does this piece of theory allow social researchers to interpret how social meaning works, in certain times and places?" As a way of understanding DIY, in its highly personal and experiential context, the intersection between constructed and pragmatically organised social theories with non-static local meanings (which are different in different times and places) acknowledges the nuances of co-production of knowledge in both social and technical senses. In other words, an AR perspective opens up a new way of conceptualising, in theory and practice,

what has been previously ignored: the unique nuances of knowledge production in DIY. This approach, complemented by considerations for structures and social shaping described above, can for example, shed light on the role of the meanings and materiality of DIY techniques and grassroots organising in leveraging production of knowledge between the scientific establishment and everyday life.

Focusing on different ways of knowing also addresses the gap in the literature of not recognising the role of technologies in knowledge production in the more 'messy' context of DIY and grassroots initiatives. For example, the multiplicity of technologies developed and used in DIY and grassroots initiatives (ranging from notepads to smartphones and DIY spectrometers) provide different ways of capturing, sharing, telling, and representing stories through personalised codes, filters, and algorithms. These technologies, and the techniques developed with them, also blur the boundaries between science and everyday life providing alternative interpretive frameworks, products and practices that enable a more diverse and rich understanding and theories about the world. Next, I briefly describe Heron and Reason's (2008) extended epistemology, I briefly explore the literature on know-how, experiential learning, reflexivity, and sense-making.

Experiential knowing. It is the perceptual awareness from being in direct face-to-face contact with a person, place, or thing (Heron & Reason, 2008). DIY often involves a deep personal connection; it opens up ways of interacting with issues and tools in our own terms. By trying things ourselves, we "go beyond our initial conceptions and open ourselves to deeper perspectives" (Reason, 2004, p. 5). Intentional experiential knowing opens the doors and possibilities of new perspectives – to new inquiry, ways of challenging ourselves and our preconceptions about who can and should. Focusing on experiential knowing enables an acknowledgement of sense-making and knowledge production at multiple levels. At the personal level, there is recognition of the power of ownership in creating tools with one's own hands. At the intersubjective level it also enables an awareness of the nuances in the process of making: coming into contact with the materials and co-makers leading to a deeper appreciation and understanding of interactions in co-operative making: tacit learning, inspirations, development of respect, etc.

Presentational knowing. As the most basic way of making sense of our experiences, presentational knowing gives shape to experiential knowing in non-discursive ways (Heron & Reason, 2008). It is a way of telling the story of our experience through DIY: re-describing stories of what is, who can do, and what it means to do. Presentational knowing is akin to 'hacking', which represents the ability to stretch and re-appropriate the functionality, capabilities, and meaning of a given system, conception, or structure beyond those that are prescribed by its creators (based on Haklay, 2013). Here, DIY artefacts such as maps made from DIY aerial photography (e.g. Dosemagen et al., 2011) serve as boundary objects providing a concrete means of representing different interests and facilitating negotiation and transformation of meaning. The photographs and the way maps are created and presented, including the annotations and symbols used, collectively give presentational meaning to community experience. At a intersubjective level "the transfer of these practices is most easily achieved in-person and on-site, through personal interactions and collaborations" and by "providing time for the development of shared norms or cultural meanings around the tools" (Dosemagen et al., 2011, p. 4).

Propositional knowing. Propositional knowing is 'knowing about' and it is expressed in intellectual terms: ideas and theories as propositions which use language to assert laws or facts (Heron & Reason, 2008, p. 373). It is the process of redrawing perspectives and envisioning alternatives. This is also where the intersection between the 'social world of the investigator' and the 'social world of the actors' becomes most apparent. Following the

example of DIY aerial photography, the maps produced present not a section of 'reality' but something that reveals who the makers are and the world they live in or would like to see materialised. Propositional knowing draws from experiential and presentational knowing: the experiences of sense-making and creating meaning by capturing imagery and mapping are given discursive form as texts (journal articles, paper-based newsletters, etc.). Through cycles of inquiry, often at the community-level of inquiry, these propositions are tested in practice and fed back into experiential and presentational knowing. These cycles give focus and clarity in transferring learning from previous action cycles to fruitful planning of the next (Heron and Reason, 2008). This is when, as an outcome of many cycles of action and reflection at the personal and intersubjective/group levels in the process of challenging and influencing policy and regulations, a guiding theory produced and published (Wylie et al., 2014).

Practical knowing. Practical knowing is in the realm of skills; it is knowing how-to-do or how to engage in some type of action or practice (Heron and Reason, 2008, p 375). It also involves creating communicative spaces that actively seek to promote dialogue and reflective practice so as to democratise research and production of knowledge. When people initiate and lead their own inquiry, working through DIY and moving into collaborative DIT, they open, develop, maintain, and foster new forms of communication and dialogue. That is, they develop the ability and capacity (highlighted by Carlile, 2004, above) to use common knowledge, represent/translate differences in new knowledges, and identify its impact/consequences. In AR a shift from DIY to DIT would be recognised as *emergent*, as practices by members of a group are acknowledged and valued in the move between different knowledge boundaries and the concomitant development of boundary objects. These ultimately shape and are shaped by the interactions in the group but also by social structures and contexts.