Participatory Design and Free and Open Source Software in the Not for Profit Sector – the Hublink Project

Submitted by

Lisa Frances Haskel

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Copyright Statement

Abstract

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Lisa Haskel

This industry-based thesis undertakes a multifaceted and longitudinal exploration of the design and implementation of a Free and Open Source Software (FLOSS) based information system in a consortium of small-scale community organisations. The research is centred on the design, production and implementation of a case management system with and for a group of nine not-for-profit organisations in the London Borough of Tower Hamlets who work as a consortium. The system, called Hublink, is based on the FLOSS framework Drupal.   The system was designed during 2013 and has been in everyday use by those organisations since January 2014, acting as the consortium's primary information infrastructure. This research therefore encompasses both design and use. The design process was based on Participatory Design (PD) principles and methods. Because of the project's long-term nature, Hublink has been an exceptional opportunity to focus on the legacy of a PD process into the later stages of the software development life-cycle. This research has therefore been able to draw on themes that have emerged through real-world use and an extended collaboration and engagement.

In this thesis I place the Hublink project description within literature covering Participatory Design, Community Informatics and Free/Libre and Open Source Software (FLOSS), extending into infrastructuring, appropriation and end user development. Through a literature review and presentation of evidence collected during this research project, a clear argument emerges that relates the mutual learning outcomes of Participatory Design, with sustainability through infrastructuring activities, while also showing how the communities of practice of FLOSS projects create an infrastructure for not-for-profit organisations, enabling them to build sustainable systems that can meet their needs and accord with their values. The thesis argues that while Participatory Design strengthens the human element of infrastructure, FLOSS provides a complementary element of technical support, via the characteristics of generativity and extensibility, and their communities of practice.

This research provides a deeply descriptive study that bridges design and use, centred on the core values of Participatory Design, contributing to the understanding and development of practices around sustainability and Participatory Design in the not-for-profit sector. The research offers a conceptual pathway to link FLOSS and Participatory Design, suggesting directions for future research and practice that enhance the connections between these two important areas of participatory production.

Table of contents

4

List of Figures

Figures in appendices

List of Tables

List of Accompanying material (CD)

1. Elearning videos (produced by Real DPO Ltd)

2. Scope document

3. Raw data used in section 5.6

Acknowledgements

Declaration

I declare that the work in this thesis was carried out in accordance with requirements of the University's Regulations and Code of Practice and that it has not been submitted for any other academic award. Except where indicated by specific reference in the text, this research is my own work. Work done in collaboration with, or with the assistance of others, is indicated as such. I have identified all material in this dissertation which is not my own work through appropriate referencing and acknowledgement.

Abbreviations

CI **Community Informatics**
See section 3.3: The study of the deployment of computing within grassroots and not for profit organisations.

CSCW **Computer Supported Co-operative Work**
See section 3.21: The study of the uses of computer-based tools for collaboration, taking social and technical perspectives.

EUD **End User Development**
See section 3.2.4: The practice of computer users customising their software tools independently from developers.

FLOSS **Free/Libre and Open Source Software**
See section 3.4: Software developed under licenses that ensure full access to source code and unfettered use.

HCD **Human Centred Design**
See section 3.1.2.4: Design methods that prioritise the human experience of use.

HCI **Human Computer Interaction**
See section 3.1.1: The study of the interaction between people and computers.

PD **Participatory Design**
See section 3.1.3: The involvement of users in co-creation of systems that they use.

Real **Real DPO (Disabed Peoples Organisation) Ltd**
A user-led charity based in Tower Hamlets that undertakes information sharing, advice, advocacy and practical support for disabled people.

STS **Science and Technology Studies**
The study of the social, political and cultural aspects of science and technological innovation.

UCD **User Centred Design**
See section 3.1.2.4: Design methods that prioritise the experience of users.

VSO **Voluntary Sector Organisation**
Organisations that undertake activities for social benefit that are not-for-profit and non-governmental.

1 Introduction

1.1 Context and Question

This industry-based thesis uses a single project to undertake a multifaceted and long-term exploration of the design and use of a Free and Open Source Software (FLOSS) based information system in a consortium of small-scale community organisations. The research is centred on the production and implementation of a custom case management system with and for a group of nine not-for-profit organisations in the London Borough of Tower Hamlets. The system, called Hublink, has been in everyday use by those organisations since January 2014. The system serves as the primary information infrastructure for the organisations, with approximately 30 new records added or updated each day and statistics on client work submitted to the services" commissioner each month.   The design process of Hublink was based on Participatory Design (PD) principles and methods and started in April 2013.

This practical project and research has been carried out under an Engineering Doctorate (EngD) programme within the model of an industrial placement which has allowed me to work on its production and implementation for over 3 years.   Through the generous framework of the EngD and an excellent relationship with project partners, I have been privileged to have had the opportunity to see this project through the development cycle: from design to adoption and on-going maintenance, and three phases of further design while in use. This "collective accomplishment" [1] has given an exceptional opportunity to focus on the legacy of a PD process into the later stages of a software development life-cycle and I have been able to draw on themes that have emerged through this extended collaboration and engagement.   In this thesis, I provide a rich description of the Hublink project linked to three main themes that, I propose, link practice and research in this case. These themes are PD, Community Informatics (CI) and FLOSS. The research question I address is:

How does a PD design process, in a community context, benefit the sustainability of a project beyond the design phase, as it moves into the phases of adoption and ongoing use?

With secondary question:

> *What specific benefits to long-term sustainability are brought about by using Free/Libre and Open Source software?*

The description of developing and implementing Hublink, together with the community partners, is a story that includes all the characteristics of a design project defined in the literature: specific contexts and constraints; the often confusing, simultaneous development of an information system with a service, and a continuous negotiation between the affordances of a

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[1]   A term used by Star and Neumann in their paper "Making Infrastructure: The Dream of a Common Language" (1996) in describing the unfolding of complex endeavours.

technology – in this case an open source system developed by a community of practice - and the actual needs and values of users and their organisations.

The main contribution of this research is rooted in practice and those emergent themes. There is no novel technology in this project. Instead my contribution is predicated on the view of technological tools as multifaceted artefacts and concentrates on the interplay of needs, contexts, design methods, communities of practice and technologies. It is this perspective that I use to draw my conclusions and contribute my findings to the academic community. However I also hope that my work can provide practical insight for the not for profit sector into methods for building sustainable ICT infrastructures within its specific values and constraints.

1.2 Themes and theoretical position

This research is positioned at a cross-over point between PD and CI and seeks to connect these research areas, in both theory and practice, with the field of FLOSS.

PD has its roots in the democratisation of the design and deployment of new technologies in the workplace and has, over more than forty years, developed into a reflective, collaborative design practice (Kensing & Greenbaum 2012).   Carroll and Rosson have succinctly identified the two imperatives that drive and shape PD. On one hand there is a "moral proposition" that people should be included in designing tools that transform their working lives and that the opportunity to do so should be creative and value their expertise. On the other hand, there is a "pragmatic proposition" that participation produces a better result (2007).   Bratteteig et. al. define the three principles of PD as: "having a say", "mutual learning" and "co-creation" (2012) . In recent years, there has been a stronger emphasis on the sustainability of PD projects, and the challenges of longer term usage (Karasti 2014).   The "mutual learning" outcome of PD, in particular, shows that PD is a set of methods and an approach that seeks to involve users not only for the benefit of the system, but also to bring less tangible benefits to the individuals and organisations involved. PD takes as its starting point a socio-technical approach, which suggests that any automation of new technology can only been seen as part of a wider system of contexts and social relationships. However, PD adds an explicit politics which puts this individual learning and social value at least equal to, or even above, efficiency and economy.

FLOSS is software produced under strong principles of transparency and openness, with freedom of use its main concern. While FLOSS is available free from cost, it is the freedom to transform the software and use it for any purpose that makes it distinctive. Through this openness, many FLOSS projects both produce and are produced by large communities who develop and document increasingly broader and more sophisticated uses of the software tools. While both participatory practices, FLOSS and PD differ markedly.   PD is primarily concerned with expanding and reflecting decision making, creativity and power in design processes in equitable ways; FLOSS is centred on technical problem-solving and issues of ownership and

control. This research makes a strong and precisely defined link between FLOSS and PD through the themes of extensibility, generativity and maintainability, linking them to "communities of practice" and bringing these themes together under the overall banner of "infrastructuring".

CI is a specific field of research that is focussed on the small scale community context and is attuned to needs, values, existing practices and the developmental potential of community organisations. Community informatics asks what ICT"s can offer to improve the overall well-being of grassroots and not for profit organisations, and how developments in networks and digital technology in general offer expanded opportunities for this sector to function (Gurstein 1997).   Literature in community informatics is attuned to the constantly changing, social and political backgrounds within which grassroots organisations operate and their overriding commitment to the groups they serve and represent (Merkel et al. 2005). Community Informatics provides a specific understanding of the context of the Hublink project.

While PD and CI deal with design and context respectively, it is necessary to look beyond these to find frameworks for understanding adoption and maintenance which are are similarly aligned with a social model. PD and allied fields have developed the idea of "appropriation" to describe an expanded and creative notion of adoption. Appropriation describes how users adjust and tailor systems to their own needs, perhaps using designed-in methods for user customisation, or otherwise   through improvisation and workarounds (Dourish & Dix 2007). End User Development describes appropriation taken to its greatest extent. End-user development suggests that systems should be designed with the explicit aim of users undertaking customisations without the help of developers. "Tailorability" is used to describe the ability of a system to facilitate this purposeful, designed-in end-user customisation.

The term "infrastructuring" has become important in PD, and brings many of these observations and ideas together.   Infrastructuring is an encouragement to think of infrastructure as a set of activities and relations that involve social processes and specific situations rather than as a set of fixed objects.   Infrastructuring describes how a project functions into a longer temporal reach than PD, taking collaboration beyond the design phase.   Activities such as tailoring that ensure the ongoing relevance of a system to its context, as well as tasks such as maintenance and repair, are key areas of infrastructuring. Seen this way, it is the diverse and active infrastructuring process, rather than a static infrastructure, that enables and sustains, and appropriation activities can be seen as essential elements of infrastructuring.

In this thesis, I link the Hublink project with the three key areas of research, PD, FLOSS and CI, extending into infrastructuring, appropriation and end user development. I outline a clear argument that relates the "mutual learning" outcomes with PD to sustainability through appropriation activities, whilst also showing how the communities of practice around FLOSS projects create an infrastructure for not-for-profit organisations, such as the partners in the

Hublink project, to build sustainable systems that can meet their needs and accord with their values.

These themes have emerged through three years work on the Hublink project which has involved ongoing collaboration with Real DPO Ltd (Real).   Real is an exemplar of a locally focussed, community organisation that prioritises providing frontline services and is backed by a strong self-help and campaigning ethos[2]. For this research, the project has been captured and reflected through a rich description that aims to express the spirit of collaboration and reflect the values shared between PD and Real.   Later parts of the project description show how the framework of infrastructuring provides a thoughtful and accurate description of the longer term activities of sustaining this project in the community-based context.   The research methods, Action Research, Design Research and Case Study Research have been key in defining a research approach that can capture the nuances of this process and provide useful and appropriate forms of validating the findings.

1.3 Structure of the thesis

This thesis begins with some essential background information, comprising of a description of Hublink in context and a short biography of the researcher. As described in the literature review, both the design and research methods used in this study emphasise their "situated" nature. Therefore it is important to locate the researchers" voice and perspective and the biography is included for this purpose.

Following this background, a review of relevant literature is presented.   This begins with the foundations of the sociotechnical approach to automation and its extension into involving users in the design of information systems using various approaches.   These approaches have provided both design methods - used in practice in my project - and theoretical pathways to understanding the role of users in developing new technologies. Next, my review moves into areas of Human Computer Interaction (HCI) related to socio-technical design, such as computer supported cooperative work (CSCW), Discount Usability Methods and Human Centred Design. Short surveys of these fields are used to provide a basis for understanding PD and how its approach is distinctive. The second section of the review looks at the phase after design, in particular how the concepts of infrastructuring, appropriation and tailorability help us describe and understand how participatory projects can continue into the long term, after the design phase. These perspectives are informed by science and technology studies (STS), that emphasises the social values embedded in artefacts, and also recognises that the usage of artefacts and tools change across contexts. Because the infrastructuring approach values and

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2   "Self help is about personal responsibility and interdependence as well as direct,local action. Its ethos is empowering and enabling rather than protective, prescriptive or philanthropic. Self help groups are formed by people who share a common problem or condition, who get together for mutual support and to find new ways of coping" (Wann 1995). Real DPO Ltd is a "Disabled Peoples Organisation" with a majority of disabled people in governance and leadership roles and with their values rooted in the social model of disability with its emphasis on removing barriers and promoting equality.

encourages collective production, it is both consistent with PD and relevant to the community sector.

Picking up the theme of specific contexts of operation, the review then looks fairly briefly at community informatics. While this is not an extensive section it is key, as it specifies the characteristics of the impact of ICTs in the not for profit sector. Community informatics sets out both the aspirations and realities of working with ICTs in the community sector and offers clarity on how these may differ from other contexts of use for example in private corporations or in large public sector projects, especially regarding the issue of sustainability.

Finally the review looks at relevant literature around FLOSS. Open Source licenses, practices and technical architectures are described and it is shown how they encourage and facilitiate "extensibility", "maintainability", "generativity" and "communities of practice".   The section describes how informal design processes are able to be successful in this context, even though the contrast markedly with industry practice (Scacchi 2002; Alspaugh & Scacchi 2013). This section shows how FLOSS development leads to high quality resources that are available to organisations and individuals at every scale of operation.

Following the literature review I present a section on methodology that outlines the rationale for the case study approach and the gathering and analysis of my research data. I look at how my work uses a combination of methodologies to present this major piece of practice as research and draw conclusions from it.   I outline the contribution of Action Research, but ultimately conclude that there is a tension between Action Research and a production project that entails a large amount of collaborative work focussed towards a "real-world" outcome. I discuss the contribution of Design Research and in particular practitioner reflection. Finally I discuss the case study method and list the various facets of the data gathered around the Hublink project. I offer a rationale for their use in the case study, how they can be validated and how the writing style and format of the Hublink project description is consistent with these methods and the overall approach.

Following the literature review and methodology section. I present the full project description. It has been a substantial challenge to arrive at a format and structure for presenting the project that accurately reflects the values of the project as a whole, describe its complexity and includes multiple voices whilst keeping it interesting and accessible for participants to read. In response to these challenges, the chosen format for most of the project description is based on a style of "exposition" suggested by the Journal of Artistic Research. This "weave" format aims to enhance academic writing with other forms of data and visual material (Journal of Artistic Research 2015). Accordingly, in this project description, writing and data are presented side by side and cross-referenced. The data includes many artefacts and extended extracts from interviews and other communications connected to the project. The project description is concluded with the presentation and interpretation of some quantitative data that has been

extracted from the development tools used in this project. This section provides triangulation with the majority of the project description that is, in contrast, based on qualitative description.

Finally, I summarise my findings, signpost future work and conclude with a reference back to my research question.

1.4 Contributions

The contribution of this research is a suggestion, reached through the case study evidence, that PD benefits sustainability through mutual learning. The case study evidence shows that mutual learning can take a key role in building capacity among users to customise and adapt the system to their own needs. In this mobilisation of mutual learning to sustainability, the concept of "infrastructuring" which includes appropriation and tailorability, is a useful way to describe and therefore potentially plan for long-term sustainability.

This research also contributes to the field by offering an evidence-based description of how FLOSS and PD relate. In the existing literature, FLOSS has been connected with PD from a number of different perspectives. Firstly; there are a number of well-documented PD projects that develop software that is licensed as Open Source, for example: the HISP project (Braa & Sahay 2012). Secondly, many PD software projects customise existing open source platforms and find this a useful way to realise research projects, (for example Hagen 2011; Stevens et al. 2009). Finally there are a number of writers who recognise the contribution of open source practices and products to developing participatory practices in general terms (for example Bannon & Ehn 2012; Botero 2013; Fischer 2003) . This research extends these themes by suggesting that FLOSS, via its communities of practice, supports infrastructuring through maintenance, extensibility and tailorability. The project description provides both qualitative and quantitative based accounts of how this takes place.

However, these two conclusions are not separate. This research links them conceptually through the concept of infrastructuring. This step is taken by observing that while PD contributes to sustainability, via mutual learning through infrastructuring, FLOSS can also be seen as an essential component of a sustaining infrastructure through its communities of practice. Moreover, FLOSS also supports tailorability and appropriation. These capacities are part of those built by mutual learning and are also essential for sustainability. A number of further questions about both the practical and theoretical links between PD and FLOSS, and their implications, are suggested in the conclusion of the thesis.

Figure 1 is a visual representation of the argument that has been drawn out of this research project, and can be used as a reference throughout the reading of this document.
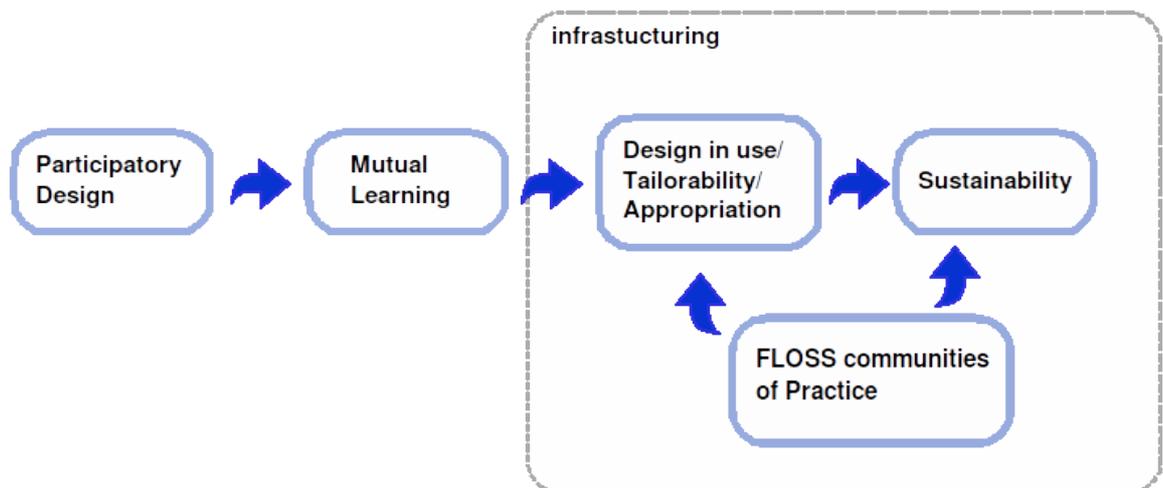
Figure 1: PD and FLOSS linked via mutual learning within infrastructuring

In more general terms, I hope that the Hublink project description illustrates the capabilities and creativity of users, the great productiveness of the communities of practice in both Open Source and grassroots communities, and how combining these forces in very practical ways can create services and systems that both promote and are sustained by communities. I also hope that this project can add to and extend the important work of the PD community that for over 40 years has brought a critical approach to the design and use of technologies in the workplace. The Hublink project was both a real-world solution and an experiment in long-term participation in building an information system in the community sector. The collective reflection on the project has illuminated both positive and negative observations that contribute to the ongoing development of participatory practice and the community sector.

2 Background

2.1 What is Hublink?

Hublink is a case management system that is used by a group of not for profit organisations who offer information, advice and advocacy services to people in the community who are dealing with issues related to health, disability and/or age. Hublink is used by individual caseworkers from nine different organisations to record and track their work. These nine organisations are working together as a consortium, called Local Link, to deliver services in the London Borough of Tower Hamlets under the auspices of a single contract with the local authority, partly delivered by a network of local information and advice services - "hubs" - at each partners" premises.

The consortium was formed in 2013 with lead partner Real. Real is a user-led charity based in, and working in, Tower Hamlets that undertakes information sharing, advice, advocacy and

practical support for disabled people.   The formation of a consortium was an initiative of voluntary Sector Organisations (VSOs) in the area, as a necessary response to changes in the funding landscape for VSOs. Put briefly, these changes were caused by central government cuts following the election of a Conservative-led government in 2010. Because of these cuts, there was less money to fund information, advice and advocacy work in the borough. Therefore the service was put out to tender as one bigger contract instead of being run with smaller amounts of money distributed directly to different organisations. The consortium was necessary as each of the existing service providers were too small to bid for this contract on their own. Because of this, the Local Link consortium was formed and the bid was won on the argument that established local organisations working together could be more effective than one larger organisation that might be new to the area. However the contract came with onerous requirements for reporting of quantitative data from across the consortium.

As a new consortium of small, not-for-profit organisations, Local Link was in need of infrastructure to support consortium working and to provide the necessary quantitative outputs for the reporting requirements. Lead partner Real had just seven months to put systems in place. Fossbox is a Community Enterprise that is an advocate and provider of Open Source based systems that is well-known in Tower Hamlets and which had been part of a project to adjust to the changes in funding called "Transforming Local Infrastructure". Fossbox was approached by Real to research this issue of consortium infrastructure. In turn, Fossbox approached myself as an EngD funded Research Engineer to get involved.   Hublink is the result of this series of partnerships; an information system based on the Open Source content management system and development framework, Drupal. Figure 2 shows all of the Local Link partners, and the partnerships that worked on Hublink.
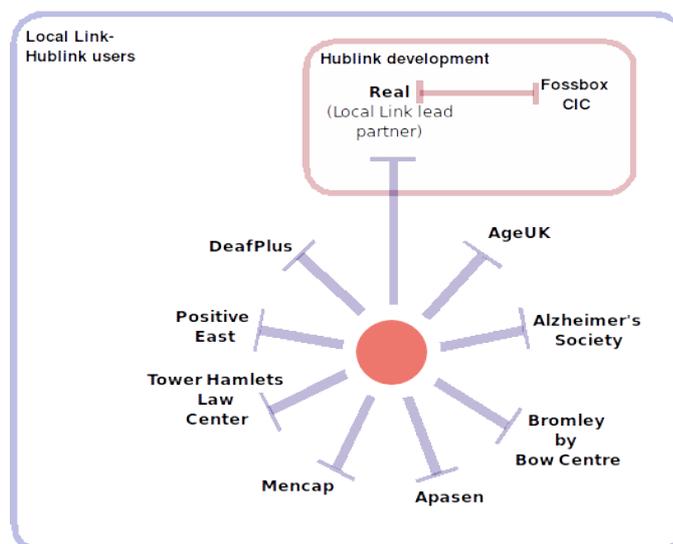
Figure 2: Hublink partners

Hublink has the following three main purposes:

1. To help caseworkers track and organise their cases and client records, giving them easy access to information and tools to prioritise their workload

2. To enable information to be shared between organisations in the consortium to save duplication and achieve a "joined up" service for clients. But information should be shared only when appropriate and when the client has consented.

3. To provide statistics about work completed and clients helped, to be sent to the commissioner on a quarterly, monthly or annual basis.

Hublink has three main types of data: *clients, enquiries*, *projects* and *notes*. Enquiries are used to log short interactions with clients for instance a telephone call or "hub drop-in". Projects are used to log longer and ongoing work with clients and can have case notes attached. The client data type stores detailed client information including equalities information and contacts. Users in the system may be workers or managers and are put into groups according to their area of work and organisation. The visibility of data about clients and projects can be restricted according to roles and these groups. Hublink generates a personalised dashboard for each user that is intended to help them organise and plan their case-load and, in the case of managers, to allocate new work within their team. In addition to the project worker and manager roles within each consortium organisation, there is an additional 'consortium manager' role which has visibility of all records across organisations.

Organisations typically have two or three staff members who use Hublink. They may have different roles: either organisation manager or project worker. Project workers may either take straightforward *enquiries* or undertake longer running *projects* with *clients*. The interaction between these different roles and organisations over the lifetime of a client's contact with the consortium concerning one issue is shown in Figure 3.

The system personalises the user interface to better facilitate the different functions and roles by showing only the information needed to perform that role.

key
- client
- enquiries desk
- organisation manager
- caseworker

Initial enquiry

Enquiry → Search for client

if not found → Create client record

if found → Create enquiry

if enquiry desk can answer → Record resolution and close

if referral is needed

An organistion search facility will be available

New referral

Create project

Multiple projects may be created for one enquiry

Send to organisation

When a new project is assigned to an organisation, an email is generated that is sent to the relevant organisationm contact. The email has a link to the relevant project

Caseworkers and managers will be able to view information about other enquiries and projects for their clients - subject to permssions and consents

Assign caseworker

Issue active

Caseworker notified of new case by email

Update Project

There may be many notes about client contact

Create notes

Caseworkers may create new projects to refer to other organisations

When issue is resolved

Issue closed

Record resolution and close → Request feedback

Figure 3: Flow diagram showing how different users work with Hublink

2.2 Some examples of how Hublink is used

Four key user journeys are provided here, supported by screenshots to illustrate the user interface. These are intended to give the reader an overview of how Hublink is commonly used and how it appears to users with different roles. Though there is much functionality not illustrated in these user journeys, these should help the reader gain an overview of the most frequent and important tasks undertaken.

The "elearning" materials that Real provided to partner organisations is included as accompanying material to this thesis which gives a further view of the application. In particular the following materials are useful; they may be watched to find out how Hublink is used.

Dashboard – module 3 "show me"

Client search and adding clients – module 4 "show me"

Creating enquiries – module 5 "show me".

Creating projects – module 6a "show me"

Adding case notes -module 6b "show me"

It should be noted that the production of these videos was done entirely by Real staff, an undertaking that is discussed in the project description as illustrating the value of the mutual learning of the PD process.

Larger versions of the key screenshots are included in Appendix 2 for better readability.

User Journey 1

Anita, a project worker at Real, needs to find an existing client and enter a new project record
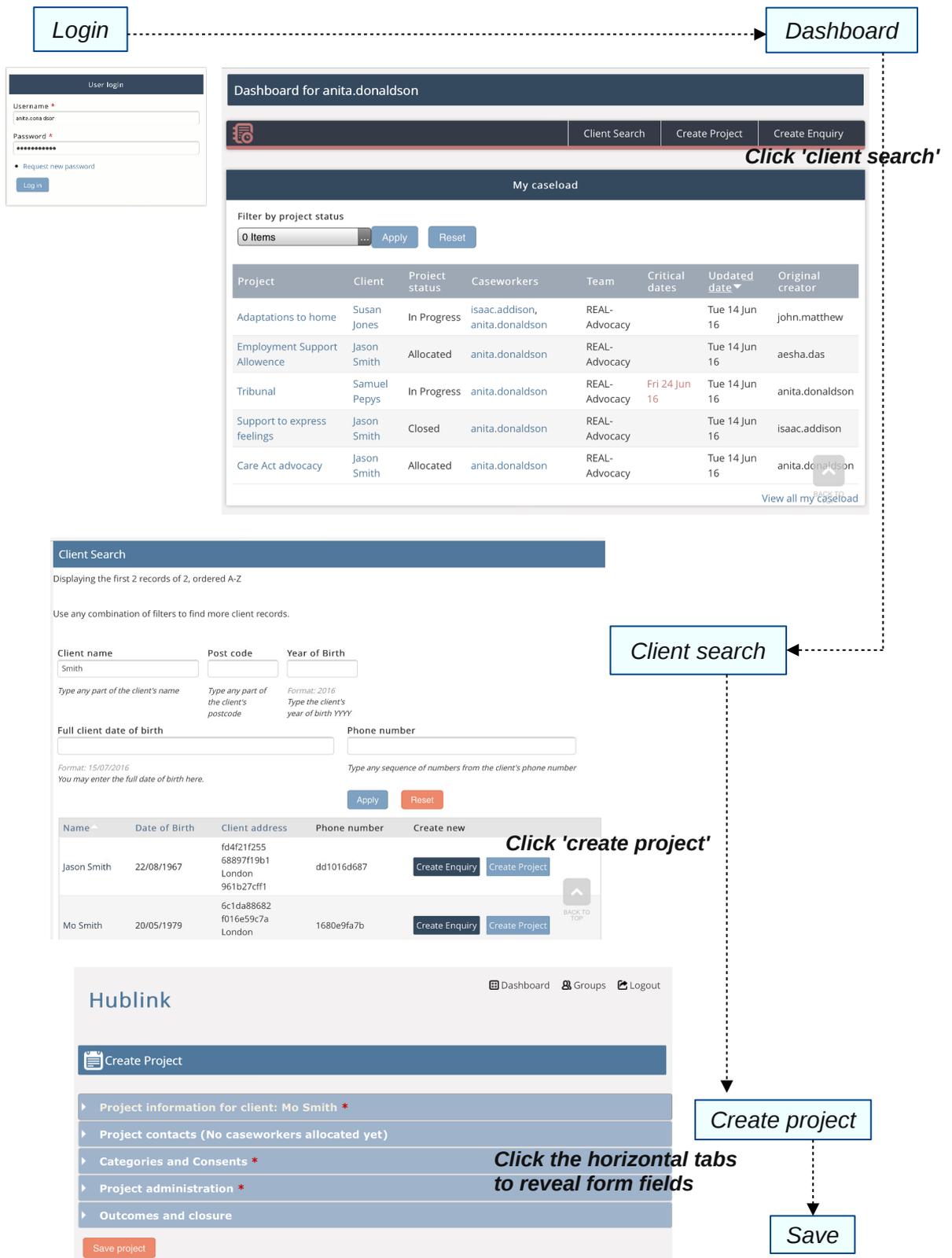
Figure 4: User journey 1 – create a project. See Appendix 2 for larger screenshot of manager's dashboard.

User Journey 2

John, manager of the Real Advocacy and Real-advice teams logs in to see if there are new referrals. He allocates an incoming referral to one of his team

Login

Dashboard

Dashboard for john.matthew

	Client Search	Create Project	Create Enquiry

Projects waiting list

Projects for your organisation that require referral or allocation.   **Incoming referrals are shown at the top of the Manager's dashboard**

Title	Client	Project status	Critical Dates	Team	Project created date	Original creator
Care act advocacy	Jason Smith	Referred but unallocated	25 Nov 15	REAL-Advocacy	1 day 4 hours ago	anita.donaldson

View projects overview page

Enquiries overview

Enquries for your organisation

Title	Client	Organisation	Team	Enquiry status	Enquiry created date
advocacy enquiry	Jason Smith	Real	REAL-Advice	Closed	1 day 4 hours ago

Edit project

▶ Project information for client: Jason Smith *
▼ Project contacts (No caseworkers allocated yet)

Caseworkers

⊹ linda.hague (93)   **Caseworker added with autocomplete**

Add caseworkers here

Add more caseworkers

▶ Categories and Consents *
▶ Project administration *
▶ Outcomes and closure

Save

Figure 5: User journey 2 - allocate a caseworker. See Appendix 2 for larger screenshot of manager's dashboard.

User journey 3

Linda, a project worker at Real, finds a new project on her dashboard allocated to her by John, and logs initial contact with the client.
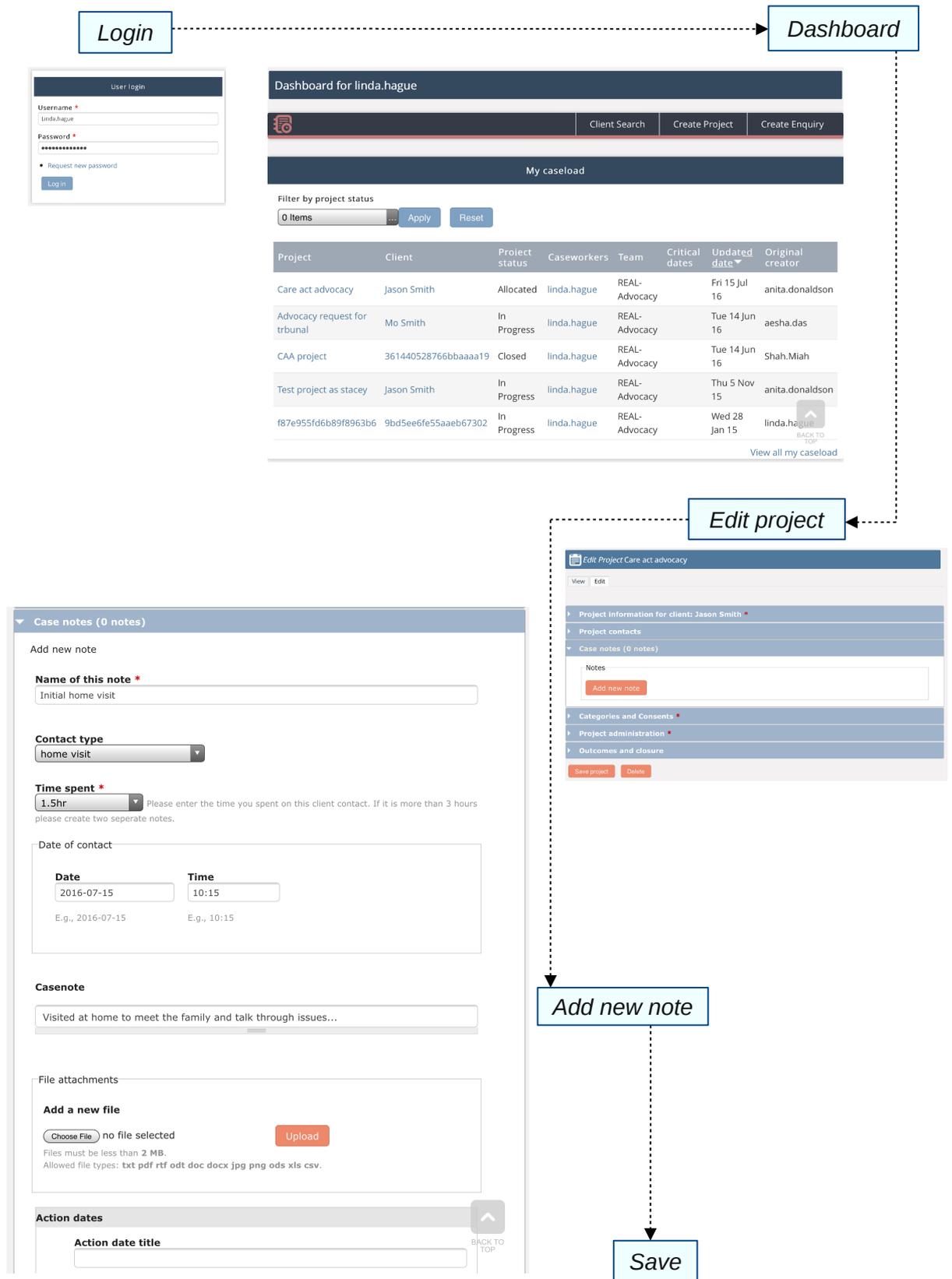
Figure 6: User journey 3 - create a note. See Appendix 2 for larger screenshots of note form.

User Journey 4

Aesha, a consortium manager, needs to check the number of enquiries being taken by Real Advocates and what kinds of issues they cover.

Figure 7: User Journey 4 - Use faceted search for monitoring. See appendix 2 for more detailed documentation of the search function.

2.3 Researcher's Motivation

The institutional and organisational background to this study is presented in the first part of this background section. However as, we will discuss in both the literature review and methodology sections of this research, the concept of "located accountability" provides important theoretical grounding to how both the practical work and the research was conducted. Located accountability (Suchman 2002) suggests that knowledge and actions are affected by peoples experiences and social positions. It is therefore necessary to position myself as a practitioner and researcher within this research at the outset. This locates my perspective, provides an understanding of my own role and underpins the rationale for the presentation format of this research.

Working on Hublink has been a unique and special opportunity for me as it unites my interest in online collaboration tools and not-for-profit organising.   Straight from leaving school in 1984, I undertook 1 year of voluntary work for Hammersmith and Fulham MIND (a large Mental Health VSO), where I was tasked with producing a directory of local organisations that, implicitly or explicitly, contributed to the mental well-being of the community. Through this work I both experienced working in a VSO and had the opportunity to visit a large number of varied organisations and services and interview their staff.   The self-help, self-organising ethos of many of these organisations, and the way that they combined campaigning and the empowerment of disadvantaged groups with providing local services were remarkable to me at the time as an 18 year old. Subsequently I pursued my interest primarily in communication – by training and working in the arts and media production and studying media and cultural studies where I primarily focussed on community involvement in media and participatory events. Throughout I maintained links with the voluntary sector both as a volunteer and in my work. I collaborated frequently with community groups and used not-for-profit organisational structures for some of my own projects. Through these connections I built my understanding, empathy and support for the values, motivations and difficulties of VSOs.

In 2003 as an already experienced practitioner in arts and media I spent one year studying Computing Science at MSc level. This switch to computing was in large part motivated by my interest in online collaboration. As an administrator and project manager working in the late 1990s, I became interested in how online systems could not only help organise events and campaigns, but organise them differently so that participants had more control and a stronger sense of ownership over activities they participated in. My interest in this grew in parallel with new web-based participatory technologies, which are now referred to under the banner of "web 2.0". From my perspective, this period of development in web technologies represented a shift from seeing the web as a repository of static content to being a set of platforms or tools for communication and collaboration that could take many forms. As a Computing Science student, I was highly motivated by the idea that as a practitioner and now a programmer I could create and control my own tools. My final project was the creation of an online system for the collaborative organising of conferences and workshops – an endeavour that I had been involved

in for several years before as an organiser. This project was a very personal way to merge the role of domain expert and developer.

After completing my MSc I went on to work as a teacher, trainer and developer and began to specialise in the Drupal framework. As a developer I worked on several medium scale projects, some of which were in the public or not for profit sector. As a trainer, among other activities, I ran one-day courses for Drupal site builders, many of them from the not-for-profit sector. Through doing this work I became increasingly aware of both the potential and the difficulties faced by non-technical domain experts in customising and organising their content. I became interested in the potential for a greater level of creative input and involvement by site builders, but also the need for a more effective and deeply involving approach to learning.

The EngD has been an exceptional opportunity to follow up these interests and to research relevant literature and practice. My collaboration with Real for the Hublink project has been facilitated by Fossbox, a Community Interest Company that specialises in the research and deployment of FLOSS solutions in VSOs, and Arts Catalyst, an arts organisation that explores the connections between art, culture and science which has provided me with a base for this work via the industrial placement that has been both generous and thought-provoking. Both organisations have been invaluable facilitators of this work.

Therefore, I bring some key interests and areas of awareness into this project from experience. In summary these are: a knowledge of and empathy for the values and working environments of VSOs in the community sector, a commitment to participation as way of building knowledge and taking control, and an interest in the specific technical skills needed for creating web-based tools for new forms of collaboration. Fossbox and Arts Catalyst have provided supportive environments and astute input.

3 Literature Review

3.1 The Sociotechnical Approach and Participatory Design

3.1.1 Introduction

> "The development of information systems is fascinating; it is a technical process
> aimed at building a computer artefact; it is a social process deliberately changing
> how things are done; it is an individual process of learning and development –
> within a larger social context of change; and it is a political process in which power
> is enacted and materialized in more or less explicit ways….Most systems
> development literature does not address this diversity, leaving the reader with a
> very limited view of the subject: the engineering aspects are extremely well
> covered in systems development literature – but there is no creativity and no
> collectivity, no people and no passion, no frustrations and no fun!"
>
> (Bratteteig, 2003 p.13)

Embarking on an Information System project such as Hublink involves consideration of a
multitude of factors and, as alluded by by Bratteteig in the quote above, the awareness that one
is embarking on a long and often rocky journey. This journey, despite the best of plans, will
bring unpredictable encounters with people, places and events. There will be tension as well as
collaboration, and difficulties to resolve together.

How a practitioner understands and prioritises these human and environmental factors
determines key decisions about how a project is conducted. Explicitly, choices about design and
engineering methods are made on the basis of pragmatic concerns. Methods that will achieve
the best result should surely be chosen. However, almost always implicitly, such decisions are
also made along ethical or political lines, reflecting a prior concept of the user and their
environment and guided by intentions that reflect the values of the project stakeholders.

This first section of my review looks briefly at how researchers and practitioners who work
under the banner of human-centred design have interpreted the relationship between users and
designers, with a focus on the emergence and development of 'socio-technical' perspectives. I
take as my starting point those perspectives that explicitly account for the social factors that
influence the design and deployment of information systems also often making their ethical and
political intentions explicit. I then touch on the relationship between the sociotechnical
perspective and the field of usability, clarifying convergences and divergences between them.
Lastly, I describe the field of Participatory Design (PD) in more detail as this is the field within
which the Hublink project, at the centre of this research, is explicitly located.

Reviewing and understanding the literature in this area has provided an encouraging and
sometimes challenging framework for my approach to the Hublink project. It has informed

how I approach and form working relationships with collaborators, how I respond to and solve problems, and it has offered a set of practical methods that harness the knowledge and energy of a team towards production. PD and related work has provided inspiring examples of practice and risk-taking steps in theory and analysis that have challenged many assumptions in software engineering and design and embedded a human-centred approach. Though the review is brief, it provides insight into the values, aspirations and problem-solving techniques that have underpinned the Hublink project.

3.1.2 The Socio-technical Approach

3.1.2.1 Background and History

The socio-technical approach takes a holistic view of an information system – or any kind of automation – and suggests that it can only be fully understood by looking at the social context of its use as well as its internal engineering. Within these perspectives the user is never seen as an interchangeable cog in the system whose actions can be predicted and measured regardless of context or individual difference. Instead, users are seen as experts in their own domain who will have unique insights into tasks and the environment, and a unique relationship to tools used. Moreover, they are seen as having much to lose or gain from a new information system entering into their work, home or community, and are essential to the long-term sustainability of a system within the environment. Following on from this analysis, the sociotechnical approach suggests the development of design practices that integrate social research and human-centred perspectives with technical methods.

Roots of the socio-technical perspective can be found in the work of Enid Mumford, a British social scientist with an interest in labour relations and personnel strategy who became an expert in designing information systems during the 1970s and 1980s. She and fellow researchers observed that the implementation of new systems of any kind often fail, summing up by saying:

> "If a technical system is created at the expense of a social system, the results obtained will be sub-optimal".

> (Mumford 1995)

Mumford used the term 'socio-technical' to describe a democratic approach to developing new forms of work organisation that involve automation. This approach was developed at the Tavistock Institute of Human Relations, set up in 1946, which developed projects around the introduction of automation in areas such as the coal industry and the textile industry. With most of its founding group associated with the Tavistock clinic, an institution mainly promoting psychology and psychoanalysis, the perspective of the Tavistock Institute was rooted primarily in promoting the personal well-being of individuals and positive group dynamics (Mumford 2006) . With this backdrop, there was always an overarching concern with personal development and social benefit in the work of this group. The aim was to design new forms of work with the objective of increasing the participation of individuals in decision-making, thereby empowering them to shape their own working environment for the better.

Mumford took these human-centred approaches to work and automation into information systems design. Mumford developed a series of well-defined methodologies for working on building systems jointly with those who are most affected by them. The methods she advocated were clearly backed by the ethical approach of the Tavistock Institute concluding that systems should be designed by drawing on the knowledge and experience of the workers themselves . Reflecting these underpinning concerns, the methodology she developed was called the "ETHICS" - Effective Technical and Human Implementation of Computer-based Systems

This highly political approach, paying close attention to the social relations of labour was not undertaken in isolation. Eminent German computer scientist Christiane Floyd also developed a methodology for developing software in collaboration with users, called STEPS.   In this work she echoes much of the work of both Mumford and of the Scandinavian researchers in Participatory Design that will be discussed later in this review. In her work, Floyd makes a far reaching critique of systems-based approaches to design, saying:

> "...they take little notice of fundamental factors such as subjectivity, motivation, individual and collective interests, power and conflict, as constitutive elements of design as social process".

>   (C. Floyd et al. 1989 p.55)

Her work tries to bring the two areas of production and use closer together, doing so with a strongly stated ethical position that advocates "humanistic work design". Floyd takes the unusual step of suggesting that software development should be seen as a process rather then a product, closer to a design undertaking than an engineering project.   Floyd quotes Peter Naur, describing software development as an 'activity of overall design with an experimental attitude', (Naur, 1974, cited in (Christiane Floyd et al. 1989 p.54). Moreover, for Floyd, this design process should lead to 'mutual learning' by both users and developers. The STEPS method itself makes strong cases for an iterative development cycle, the production of prototypes and the actual use of the software throughout its development life cycle.

Concurrently with the work of Mumford and Floyd, a body of work was developing in the Nordic countries under the broad banner of Participatory Design. PD had much in common with the work led by Mumford and Floyd, and both researchers surveyed and wrote about PD (C. Floyd et al. 1989; Mumford 2006). However, PD had a different political setting to either Britain or Germany; PD developed together with legal and institutional support for the implementation of work practices that should benefit the wellbeing of employees (Bratteteig 2003). This factor amongst others means that it has its own trajectory, one which we return to in the next section of this review.

Socio-technical design outside the Nordic context has been taken in a number of different directions since the early work by Mumford and Floyd.   Nevertheless, it has been argued that there have been significant barriers to applying the socio-technical perspective and socio-technical design is not widely used in the industry. Baxter and Sommerville, despite being strong proponents of the socio-technical perspective, argue that the insights of socio-technical

analysis have not been matched by well defined design methods, in particular, methods that can be applied by engineers within their standard practices and familiar terms of reference. They go on to argue for an extension of socio-technical design into socio-technical software engineering, in which methods are pinned down and integrated into software engineering design tools and notations such as the UML which are widely used to make the bridge between analysis, design and running code (2011).

The view that STD has not been widely taken up is also investigated in an article by Edith Mumford that reviews the history of socio-technical design from her perspective. This article was published in 2006, the year of her death at the age of 82. Mumford suggests that the political tide turned against the idea of humanistic work in around the 1980s with the adoption of management principles such as Lean Production. Mumford suggests that although Lean Production includes potential benefits to workers such as 'multiskilling, feedback to management and continuous improvement' (2006), its overall aim is to standardise work for the purposes of efficiency. In Lean Production, workers are not in control and their work is 'faster, more streamlined and more stressful'. Mumford additionally raises some extremely pertinent questions about the future of workers' involvement in automation, foreseeing the increasing casualisation of labour and contracting out of services as bringing new and ever greater challenges for the acceptance and practices of her ideas and methods (2006).

3.1.1 Human-Centred Design, HCI and usability

The proponents of socio-technical design such as Floyd and Mumford, together with researchers and practitioners within the Nordic tradition of participatory design are among leading practitioners concentrating on the social and organisational aspects of the use of computer systems. However, there is another, large body of work within computer science that takes the interrelationship between humans and computers as its subject. This is the wide and varied area of Human Computer Interaction (HCI, sometimes also called computer-human interaction - CHI). Much of HCI contrasts with work discussed in the previous section by focusing on the interaction of individuals with computers rather than, in the socio-technical approach - foregrounding the social context and political issues such as power and control. However, computers and users are the subject of both areas and so there are both divergences and convergences between the socio-technical approach and different areas of HCI.

Just three areas of HCI are discussed in this review. They have been selected because they have relevance either to methods used in the project, or because they illuminate later discussions about FLOSS and Community Informatics. Or they may be included because they contribute to understanding the distinguishing characteristics of socio-technical approaches in general and PD in particular. This understanding may come either through a convergence of concerns or, as in the case of the first area of concern - the 'Model Human Processor' - by focussing on differences and contesting underlying assumptions.

3.1.2.2 Challenging the 'Model Human Processor'

Much early and continuing work in HCI has focussed on the user interface. Making a distinction between the system and the interface is based on the idea that a system can be treated as a kind of black box and the job of designers is to create an interactive layer that best enables a user to access the functions of the machine without wanting or needing to know about its underlying workings. The majority of work in HCI evaluates user interfaces and proposes new ones; examples might be interfaces that use gestures, touch or even brain waves to control computerised devices of all kinds.

The "first wave"(Bødker 2015) of HCI was based in experimental psychology. Pioneering researchers such as Stuart Card, Thomas Moran and Allen Newell developed the notion of the Model Human Processor (MHP), which sought to find ways to measure, generalise and apply calculations to a user interface based on quantitative data gathered about human behaviour. Examples of such data are: the time taken to receive visual input, to process working memory or to reach out and press a button. This work led to approaches such as GOMS (Goals, Operators, Methods and Selection rules) and KLM (Keystroke Level Model). These analyses were extended into empirical methods for breaking down a user interaction into constituent parts to which calculations could be applied which would then reveal the quality of user interfaces.

The details of these approaches are not significant for us in this context. The significance for us is the underlying conception of a human as standardised and interchangeable. It is the rejection of this approach that differentiates the socio-technical approach in general and PD in particular from other areas of HCI. The work of Terry Winograd is notable here, publishing 'Computers and Cognition' in 1986 in collaboration with the Chilean philosopher Fernando Flores. In this book, Winograd, speaking from within the discipline of Computer Science, argues strongly for an approach to designing computer systems that is strongly grounded in philosophical ideas that describe a complex interplay between tools, language, human understanding and experience, in contrast to a rationalist approach that "explain the operation of deterministic mechanisms whose principles can be captured in formal systems" (Winograd & Flores 1986 p.14).

Through the late 1980s and early 1990s, a series of researchers took up these critiques of the rational, experimental approaches to HCI, and from these critiques built up alternative theories and practices.

Writing in 1995, Kari Kuutti, in no uncertain terms , points to the shortcomings of the cognitive science approach, showing that it largely fails to explain real-world results or contribute to successes that are seen in actual industry practice. Kuutti tracks the progress of HCI research noting a rising tide of arguments "against the use of information processing psychology" and the emergence of questions that probe the political and practical "realities of system design". These approaches also resist the paradigm of studying people "as objects to be modelled"(1995

p.2). Liam Bannon, in a book chapter called From Human Factors To Human Actors, makes an equally forceful case for pursuing new directions in HCI research saying:

> "I believe that there needs to be a better understanding among researchers, and many system designers too, about the "users" of computer systems and the settings in which they work. Part of the problem resides in an implicit view of ordinary people which, if surfaced, would seem to treat people as, at worst, idiots who must be shielded from the machine, or at best, as simply sets of elementary processes or "factors" that can be studied in isolation in the laboratory".

> (Bannon 1991 p.25)

Bannon makes explicit how ones theoretical point of view determines ones concept of the relationship between user and engineer. He sees the lack of respect for the individuality and expertise of users as a symptom of a world-view in which users are "passive" and "depersonalised" (1991 p.26).   By contrast, he sees those active in the Nordic Participatory Design movement but also Americans such as Terry Winograd and Lucy Suchman, whose work we will look at later, as presenting radical alternative points of view about how design in relation to computer systems can and should be practised.

For the Hublink project, Bannon's contribution encapsulates the underlying position of this research project; a position that suggests that our choice of design methods are, first and foremost, political and ethical and depend on a view of computer users as active and empowered. This position is especially important for this research as the ethical view of the empowered individual provides the overlap on the level of values with the values of the the not-for-profit sector which provides the context of the Hublink project.

3.1.2.3 Discount And Lightweight Methods

A second critique of the cognitive science based methods in HCI is that they are too detailed and therefore too expensive to be practical for software projects of modest scale. This argument has become especially powerful since the early 1990s with the move towards web technologies. This shift has meant that there are far more people working on relatively small software projects that nevertheless require some level of usability design, evaluation and improvement. In response to this we have seen the emergence of several so-called 'discount' or 'lightweight' methods which have enabled a greater range of practitioners to apply at least some insights from usability research to small projects.

A pioneer of lightweight methods is scenario-based design. This method is especially interesting for this part of the review as it was first devised by John Carroll and Mary Beth Rosson. Both Carroll and Rosson are prolific figures whose work has spanned my review's major areas of concern: HCI, Community informatics and Participatory Design.

The scenario perspective	The "establishment" view
concrete descriptions	abstract descriptions
focus on particular instances	focus on generic types
work driven	technology driven
open-ended, fragmentary	complete, exhaustive
informal, rough, colloquial	formal, rigorous
envisioned outcomes	specified outcomes

Figure 8: Contrasting perspectives on system development: The scenario perspective and the establishment view. Table by John M. Carroll taken from 'Scenario Based Design', Handbook of Computer Interaction, 1997, p. 385 (Carroll 1997)

Scenario-based design was developed initially in the 1990s. The authors recognised that designing for the fast expanding world of computing was becoming less a set of technical problems around constraints such as speed and memory, and more a set of communication problems between people. Rosson and Carroll recognised that an engineering approach, with the aim of generating a complete and abstract specification, might not always be necessary or even impossible. The table in Figure 8, reproduced from Handbook Of Human Computer Interaction, 1997 edition, succinctly summarises this looser approach compared to a conventional software engineering practice.

At its root, Scenario-Based Design is about storytelling. It suggests that the way to elicit a rich description of an activity in order to design for it is to ask people to tell stories about it. The stories may be about envisioning a new or improved system, or may take a step back and describe an existing workflow that is going to be automated or enhanced via computing in some way. This very simple idea and set of principles has been adopted and integrated into may user-centred and participatory methodologies and has been shown to be a very effective and inclusive way of making design methods available to a much broader range of practitioners. For the Hublink project, we used scenarios extensively, in the form of role-playing exercises.

Jakob Nielsens 'Discount Usability' methods, also developed during the 1990s, have allowed a great range of designers and developers to evaluate the usability of their work in a practical and pragmatic fashion. (Neilsen 1993). Some of Neilsen's methods to evaluate user interface can be done by developers, for instance the "cognitive walkthrough", in which developers define tasks for themselves and carry them out step by step, spotting problems and inconsistencies along the way. Developers may also apply heuristic evaluation to their own work. For this technique, Nielsen defines a general set of rules for good practice for interface design that is then applied to the interface in order to find faults. These rules include ensuring that error messages are useful to the user and that there is consistency in the interface design applied by the developer. Discount Usability is concerned with the user's point of view and recognises the user's unique context. One of its primary principles is to "speak the users language" and to adhere to already familiar conventions. A complementary, user centred test that is also part of the Discount Usability set of techniques is "thinking aloud". This procedure asks users to complete tasks while "verbalizing their thoughts" (Neilsen 1993 p.18) as they use the system. For this task it is envisaged that these tests might take place with a user and developer or tester

sitting together, with careful note being taken of any problems and any inconsistencies between the developer's prediction and what the user thinks is being indicated to them by the interface (Neilsen 1993).

Discount Usability is included in this review for two reasons. Firstly because, in outline, it provides useful tools that can be integrated into a user-centred design project. They are also indeed simple and cheap and as such useful in the community context. The user-centred techniques such as "Thinking Aloud" are transparent and collaborative, compared to the fixed roles of a lab situation. Many elements of Discount Usability were used in the development of Hublink. Secondly, the development of these methods indicates a further step away from experimental interface evaluation towards lighter-weight, pragmatic techniques. Discount Usability recognises, to some extent that users operate in unique contexts but it does not cover methods for discovering more about those contexts.

Discount usability and lightweight methods can be seen as part of a trajectory away from experimental approaches to working with users, with the work of Neilson primarily motivated by pragmatic concerns and widely accepted within industry. The work of Carroll and Rosson has a stronger ethical dimension and converges with the critiques of cognitive science-based approaches to HCI that have also been discussed in this section. It is this balance between the pragmatic and the ethical, and the journey away from the model of a standardised user that we discuss in the next section.

3.1.2.4 Human Centred Design

The strong statements from Bannon, Kuutti and Winograd discussed in the previous section are examples of critiques and proposals for alternative points of view to cognitive science-based approaches to usability. We have also seen how lightweight methods and Discount Usability testing show that understanding users and finding out about their point of view are effective ways of improving design. Some further developments of these alternatives have resulted in the fields of "User Centred Design" (UCD) or "Human Centred Design". (HCD).

UCD and HCD are broad terms, used almost interchangeably. In UCD, the end users of any system, product or service should be taken into account at every stage of the design process. HCD is broader; in HCD, designers should take into account the needs of all human actors implicated in a design problem, not just end-users. In both, however, the guiding principles are clear. Contact with actual people in their own context is a mandatory requirement and feedback from them should be treated as fundamental information for development and improvement. In UCD/HCD projects one might expect at least some element of prototyping and iterative development; accessible and hands-on opportunities for users to give feedback before a design is finally completed are indispensible.

UCD/HCD comes in a large number of different forms, and is widely used in many areas of design including urban planning, product design and architecture. However, keeping in mind

that the purpose of this review is to provide a background and theoretical context to the Hublink project and its positioning within PD, I suggest that the key issue for differentiation between variations of HCD/UCD is in how they embody different ideas about participation. Rather than attempt an exhaustive study, I highlight three well-documented forms of HCD/UCD that are related to Information Systems Design. These three areas are contextual design, experience-based design and the model of human centred innovation outlined in the IDEO 'Design Kit' publication. I briefly describe these as methods and approaches, and then tease out their underlying approach to participation.

Contextual Design is a design methodology developed by Karen Holtzblatt and Hugh Beyer in the 1990s. It has been widely used in Information Systems design. Like the socio-technical approaches already discussed, Contextual Design is motivated by a wish to develop better systems by finding ways to extract and expose the full knowledge of workers about their day to day work.   For Hotzblatt, workers are without doubt the experts in the work that they do, but their knowledge is often undervalued and invisible. She says "Many important aspects of work are invisible, not because they are hidden, but just because it doesn't occur to anyone to pay attention to them". She adds "A design process needs to externalize the unarticulated knowledge behind intuition"(1997, 36). In this method, the designer/researcher must always go to the actual place of work where the emphasis is on ethnographic observation and focussed discussion that leads to insight and knowledge about the workplace. Contextual Design suggests that the model relationship for the researcher and the subject should be master/apprentice (where of course it is the researcher who is the apprentice, seeking to know by questioning and observation everything possible about the work of the master.).   Data gathering is followed by data analysis and a number of methods are described by which the raw data is structured so that interpretation can take place. Interpretation of data is done by the design team which is intended to spark off a series of design ideas. These ideas can then be tested through iterative prototyping sessions with users (Beyer & Holtzblatt 1997)

Contextual Design draws out many useful insights and suggests methods and approaches that are very usable and effective. Its use of prototypes to enable discussion stimulated by concrete artefacts is a useful method across many HCD approaches, including PD, and was a key strategy for Hublink. Contextual Design also makes an important contribution in its recognition that introducing software also has an element of "work redesign" , where the work itself will change when the tool is implemented (Beyer & Holtzblatt 1997). This was also found to be the case in the Hublink project.

However, while many of Contextual Design's methods and insights are recognisable across Contextual Design and PD, there are important differences. These differences centre on the approach to participation and participants. In Contextual Design, users are not decision makers. One of the problems Contextual Design sets out to solve is the unarticulated nature of the knowledge that workers have about their day-to-day activities. Contextual Design takes a pragmatic approach to surfacing this knowledge, setting up studies and interviews so it can be surfaced for the researcher, and so that researchers and designers can take data about it away to undertake design activities amongst themselves. As we shall see, this is in contrast to a PD approach that would emphasise instead capacity building and mutual learning that can surface

that knowledge to all participants, channelling this knowledge towards co-creation, with participants and designers working together.

As a contrasting perspective, Experience-Centred design has been a field developed in HCI primarily by Peter Wright (Newcastle University) and John McCarthy (University College, York). that argues for " qualitative and interpretative" approaches to design, as opposed to experimental methods.   They take as a starting point the notion of "Technology as Experience" (2010) in which technologies are seen as embedded in everyday social life and our interaction with them involve all our senses, cultural knowledge and emotions. Like the writing of Bannon and Kuutti, their approach is an explicit reaction against the experimental evaluation of products and user interfaces. They also explicitly distance themselves from the design of consumer products, instead concentrating on outputs and processes that are "socially, politically and personally meaningful" (2010 p.9).

The book cites a very wide range of contributions from philosophers such as Mearleu-Ponty on embodiment and John Dewey on philosophy of experience. Art practice is valued for its insights into dialogue between different groups, and attention to the detail of relationships. All these perspectives are brought together to provide a theoretical underpinning for a practice based on these values. Empathy, responsiveness, attentive listening, mutual learning, collaboration and respect for tradition are the core qualities and values the authors recommend for experience-based design. Critical reflection is an essential part of the research process.

Wright and McCarthy's Experience-centred Design takes a broad and unstructured approach to participation, focussing on qualities such as empathy and shared experiences above matters of ethics, politics, co-creation and power relationships which as we shall see are key concerns for PD. However, Experience-centred design brings a refreshing breadth of views into the field, generously allowing a range of disciplines and practices far outside of engineering to be seen as having value and challenging engineers and systems designers to think in very different ways. It suggests a design practice that is based in on the personal and experiential and shows how what some might see as a mere product becomes something embedded in peoples lives, affecting and informing their feelings and emotions beyond being a simple tool fitted to a task. The effects of designing together, taking into account all participants' feelings and emotions were observed in the Hublink project in both positive and negative ways. It is also the case that, for us, the quality of relationships with our partners and building up trust and empathy was at least as important as gathering data.

Finally we look briefly at Human Centred Design as expressed in the publication Design Kit: The Field Guide to Human Centred Design published by the design studio IDEO (2015). It is important to look at this work and the models of participation that are implicit within it as this version of Human Centred Design has been an influential and highly visible part of recent developments in thinking about design and innovation outside of academia. As Bjorvinseen et al have pointed out, this relatively new work has taken 'design thinking' into expanded realms, suggesting 'design for social impact' and 'design for social innovation' as new fields where design methods can contribute; fields that are concerned with social interactions rather than

designed objects (2010). One effect of this shift is that the results or products of innovation can now be extremely diverse. For instance, they are as likely to be a social intervention or a new organisation as they are to be a system or product (Björgvinsson et al. 2010).

Though the Design Kit publication is intended as a practical handbook, much is revealed about the overall approach to design and social problems that underpin this version of HCD. The handbook begins with a declaration that:

> "Embracing human-centered design means believing that all problems, even the seemingly intractable ones like poverty, gender equality, and clean water, are solvable"
>
> (IDEO 2015 p.9)

The introduction goes on to describe how designers can, if they stay 'grounded in what you've learned from people', solve those problems through designing products, services and organisations. The handbook then provides a number of different methods from conventional methods such as interviews, to more innovative methods such as the use of 'conversation starters'. This is a variant of the idea of the "cultural probe" (Gaver 1999) in which activities, images or tasks are designed as a means of learning about the issue at hand. Several examples are given: a board came, a card sorting exercise and some visual probes. The handbook goes on to cover recruiting participants, doing fieldwork and then synthesizing ideas in the design studio. Iteration and prototyping are also recommended (IDEO 2015).

Through this very short summary we can already gain some insights into IDEO's approach to participation. Firstly, we see that this approach does not see social problems within a political frame with its declaration that all social problems can potentially be solved through design. Secondly, although useful and innovative methods for working with users are suggested, it is clear that, for this variant of HCD, participants are seen as informants and not partners.   As in Contextual Design, the purpose of participation is to gather data while the creative processes happen in the studio only among designers.   The work of IDEO and similar institutions such as the Stanford d.School are of interest as they have broadened the scope of design and introduced HCD methods in accessible ways to a broader range of designers. However, as we shall see in the next section, these methods lack the full commitment to co-realisation and mutual learning that characterises PD.

3.1.3 Participatory Design

Participatory Design can be seen as a sub-section of both UCD and socio-technical design. It shares with the socio-technical approach a concern for common social conditions and individual well-being and emphasises working with users. However PD is distinctive and more tightly defined. In this section we see how PD both extends the goals of socio-technical design, and adds the new ingredient of co-creation. PD takes the goals of social and individual improvement

from Socio-technical design and shares methods for gathering information from potential users. However, PD extends these concerns by paying close attention to the power relationships in the design situation, and develops an awareness of the social and organisational hierarchies that determine whose voices are heard most loudly. The responsibilities and accountabilities of designers and indeed all participants, are explored in far reaching ways. In PD the goals of improving social and personal well-being are always given high priority, and 'mutual learning', an outcome mentioned in some socio-technical literature is fundamental to a PD project. PD goes beyond being a variant of sociotechnical or Human Centred Design through its insistence upon co-realisation. PD insists that users are not simply consulted or studied and seen as a source of data. In PD, the design process should enable people to step beyond being informants and become co-creators. Accordingly, Bratteteig et. al. define three 'core perspectives' of PD as follows:

- – "Having a say"

- – "Co-realisation"

- – "Mutual learning"

(Bratteteig et al. 2012 p.117)

PD provides the foundations for the Hublink project; my work is both inspired and informed by PD. While as the the project description explains, the realities and constraints of the project meant that the development of Hublink could not adhere to every aspiration of PD, PD provides the overall framework for my activities, guides decision making throughout my work and feedback from partners shows that the project achieved many aspects that PD strives for. Consequently, I have used these three core perspectives as a tool for structuring my project description, and the presentation of my data and evidence. Therefore, to give grounding to the Hublink project description, I now explore these three concepts in more detail. I also look further at the necessity to see PD as a 'situated design' practice (Greenbaum et al. 1991; Simonsen et al. 2014)and 'situated action' (Suchman 1986)as a way of understanding the interactions of users with their toolsand of describing the baseline ethics of PD practice.

3.1.3.1 Having a Say

The moral or ethical requirement for users to 'have a say' in the design of a new system is strongly rooted in the social and political context of the Nordic Countries. In the 1970s in Denmark, Sweden and Norway laws were passed that legislated the requirement for companies to involve workers all decisions that affected their workplace, including the introduction of new forms of automation (Mumford 2003; Bratteteig 2003; Kensing & Greenbaum 2012). Moreover, these laws gave a responsibility to companies to not only protect their workers from harm, but also to promote their well-being. Part of this was workers inclusion in "co-determination" through workers' councils (Bratteteig 2003 p.13).

These principles strongly resemble the work done by Mumford and others in taking a view of workplace change, including the introduction of potentially de-skilling new technologies, as political activities with social effects. However, being enshrined in law, they created a stronger institutional basis for PD to develop. This enshrinement did not however, lead to straightforward procedures or solutions. Researchers and trade unionists found that providing a forum for workers' input was not enough; workers also needed access to knowledge to help them exercise their decision-making powers. For workers to ensure they could represent their interests, new strategies had to be found for workers and engineers to exchange expertise to exercise their right to co-determination effectively. Put more strongly; the purpose was to 'boost workers' power in relation to managements' technology initiatives' (Kensing & Greenbaum 2012). Although these projects from the Nordic countries share much with the British socio-technical approach as developed by Mumford, its political approach was different. Mumford's work was respected but also strongly critiqued by Nordic practitioners for its lack of recognition of the dominance of management in decision making or strategies to even out existing power relations in organisations (Kensing & Greenbaum 2012).

Against this background, in the 1970s and 1980s, a number of projects from the Nordic countries were well documented that tested the limits and possibilities of these legal requirements and political concerns. These projects have created a canon of the PD tradition and are well documented elsewhere, particularly in the "Routledge Handbook of Participatory Design, published in 2013, which provides a comprehensive overview of PD practice. An earlier collection of writing on the same topic is Design At Work edited by Joan Greenbaum and Morten Kyng, published in 1991, which discusses many of the same projects. The PD community seems justifiably proud of these efforts and subsequent reflections, and continues to be strongly bound together by its heritage. These key projects include the Norwegian NJMF project from 1970 – 1973, the Swedish DEMOS project carried out by Ehn and Sanberg in 1979 and the Danish UTOPIA project, in which Pelle Ehn worked closely with skilled typesetters from the print industry in 1981-4 (Kensing & Greenbaum 2012). More up to date examples of long-running projects that are based on or involve a significant amount of PD are the Heath Information Systems Programme (HISP) (Braa et al. 2012)and a series of projects for the Global Fund for Women. (Trigg & Ishimaru 2012).

The Nordic perspective and its activities converge with new ways of thinking about technology design coming from other academic positions. We have seen in the previous section how some of the fundamental cognitive science based tenets of early HCI were challenged by researchers who resisted the idea of a standardised user whose actions could be expressed as simply another factor in a calculable system. However, convergence in thinking also happened with areas of Science and Technology Studies and Anthropology whose researchers were engaged in critiques of scientific knowledge and practices. These perspectives were critical of an unquestioned, scientific practice based on repeatable experiments, a singular view of objectivity, and their lack of reflexivity. The integration of these critiques into PD practice have had far-reaching influence.

A number of key writers in this area came from an explicitly feminist perspective that questioned the role of power relations in accepted scientific knowledge creation and scientific

practices. Researchers and practitioners related to information systems design and research, such as Lucy Suchman and Joan Greenbaum, brought the idea of 'situated knowledge' into their writings and practices. Situated knowledge, a perspective developed by feminist philosopher of science Donna Haraway, introduces the idea of 'partial perspective', arguing that knowledge comes from a set of situated perspectives rather than one singular, objective view that ignores the position of the knower. This position points to the possibility a better way of knowing that combines partial perspectives and takes differences in the embodied experience of the knower into account (Haraway 1988).

These theoretical concepts have become embedded into PD and have shaped how "having a say" is put into practice in a PD project. Firstly, these perspectives reinforced the view that creating and communicating knowledge must be seen as a process and a collaboration. Secondly, they underpin the view what becomes accepted or valued knowledge is determined by the power relationships between the different knowers and thirdly they show how knowledge is tied to a specific situation.

With this multi-layered approach to what it means to have a say and some complex theoretical perspectives to guide how that may be facilitated in practice, much work subsequent to the canonical early PD projects has looked carefully and critically at the actual power relations in PD projects. In the next section of this review we survey PD methods; blueprints for design practices that have been developed that take an appropriately complex and critical view of the simple idea of having a say. Such methods aim to identify and level power relations to give depth and critical perspective to this seemingly straightforward goal. Further research shows how this goal becomes all the more complex when working across a variety of cultures, countries and/or institutional frameworks such as the DHIS or Global Fund For Women projects.

In PD therefore, having a say is a complex requirement. It is not only a matter of providing a channel for communication and listening. Having a say in PD requires facilitation that is able to combine perspectives to create a unique whole that is reflexive on its context and able to tease out knowledge relevant to the situation. It is a notion given depth by critical work on design methods and power relations and remains a key concern for practitioners especially in a distributed and globalised environment. However, the PD process goes beyond ensuring that people have a say. The second core perspective is co-realisation, in which people's say is put into the design process and transformed into material outcomes which still bear the hallmarks of their ownership. In the following section we explore this distinctive quality further and look briefly at some design methods, which have been developed to facilitate both having a say and co-realisation in practice.

3.1.3.2 Co-realisation

> "Design - the interaction of understanding and creation"
>
> (Winograd & Flores 1986 p.4)

Co-realisation is, I suggest, the core distinguishing feature of PD. As we have seen, PD involves facilitating multiple participants with different perspectives to share their expertise and express their point of view. However, co-realisation goes beyond this, inviting participants to also input creatively to design solutions and decision making.

The emphasis on co-realisation opens a whole host of challenges and opportunities for design methods and processes in practice. In PD, it is not enough to gather data about use and context, Participants must also start to work as a group to co-create solutions. This requires users and designers/developers to at become a team and learn to listen, respect and trust each other at a high level. This makes the PD working relationship highly demanding for all concerned and requires great sensitivity and creativity in its execution.

For PD practitioners, co-creation itself requires creative solutions, demanding inventiveness and resourcefulness in setting up situations within which 'having a say' is facilitated and then extended into a collaborative, creative process. As Mette Egger Eriksen says, the "facilitation – or staging – of participation is central in PD processes" (2012 p.135). In PD therefore, the role of the designer can be seen as one of the creative facilitator.

Over the life of PD, many practitioners have developed and shared design methods to channel this collective creativity (for example Bratteteig et al. 2012; Simonsen et al. 2014). However, it is important to note that, in PD, methods can be applied loosely. In the Handbook Of Participatory Design, Brattetig et.al encourage practitioners to use methods as guidelines rather than recipes, and practitioners are encouraged to see methods not as hard-and-fast instructions but as "generalisations from a vast amount of empirically based 'experiences' on how to conduct Participatory Design" (Bratteteig et al. 2012 p.118).

In the Hublink project PD methods have been used exactly in this way. Methods such as Affinity Diagramming and scenarios were used in streamlined ways that were realistic for our situation. Affinity Diagramming is described by Simonsen and Friberg (2014) as a collaborative method for data analysis, but variations of it may also used in many different settings as a collaborative 'brainstorming' tools in which the group is the source of the data. The overall aim is to facilitate a 'bottom up' approach where data is gathered, and grouped in a collaborative process. As Simonsen and Friberg point out, this can be seen as a form of 'Grounded Theory' in which issues emerge wholly from the data gathered. Such data gathering or analysis may be followed by 'problem-mapping' processes, in which the emergent themes are analysed. Only after these two processes can hypotheses be suggested and then, through these, solutions

emerge for discussion. Typical tools for these tasks are coloured sticky notes, coloured pens and a large table or wall space where participants can freely circulate (Simonsen & Friberg 2014).

The use of scenarios for design was first suggested by John Carroll in the 1990s and, as has already been discussed, was very important in the development of the idea of the 'lightweight methods' that, as we have seen in the previous section, have transformed approaches to systems design as well as providing a rich tool for facilitating co-creation (Carroll 1997). Some designers have also made use of 'design games' which often resemble board or card games. In a survey paper from 2006, Brandt shows how design games extend scenarios into new territories by testing how people respond to different rules and constraints, aim to harness sociality and fun and bring to the surface how social processes such as negotiation, and common understandings may influence behaviour (Brandt 2006). We did not use any design games in the Hublink project, but their mention here underlines that the PD practitioner has a rich palette of methods at their disposal and, recognising each design situation as unique, is encouraged to look carefully at their own design situation and goals in order to choose and most importantly adapt methods. Designers must also be prepared to confront and challenge assumptions about their own roles and expertise (Bødker et al. 1991)

Taking a more theoretical overview, Muller and Druin (2003) have proposed that PD can be seen as a fertile 'hybrid space', outside of established disciplines or areas of study. They suggest that this space is highly productive because of its basis in dialogue and discussion, and emphasis on collective action. Muller and Druin take inspiration from cultural theorists such as Homi Bhabha who propose "hybrid" or "third" spaces as overlapping fields between seemingly separated domains. Bhabha's contribution was to create a new formulation of culture and individual identities in the post-colonial era. Instead of seeing indigenous cultures and foreign, coloniser cultures as totally separate, he suggests that a "hybrid" identity is created, formed from elements of both while also being new (Bhabha 1994). Muller and Druin propose that PD methods such as workshops and prototyping create an analagous third space in which creativity, together with increased understanding, takes place within, between and beyond disciplinary boundaries (Muller & Druin 2003). This perspective is of interest as it finds new ways to align PD practices with progressive politics, representation and analysis of social power into new domains, beyond the traditional leftist politics of power struggle between employers and workers. This perspective also provides insight into how such design methods can are able to build complementary qualities to the relationship that also facilitate shared working, notably trust (Parra et al. 2015) as well as mutual learning as we discuss in the next section.

These creative, collaborative methods, developed within PD, have made a major contribution to the design world. Many versions of these methods are now familiar in the work of high-profile 'social innovation' and 'participatory innovation' and 'user centred innovation' activities through organisations such as IDEO and Stanford University's d.School (Bjögvinsson et al. 2012), as well as being familiar to practitioners in the relatively new fields of 'user experience design' and 'service design'.

Co-creation therefore is the distinguishing feature of PD and I would argue its most demanding requirement. Nevertheless, it leads to great benefits. Not only is there the challenge and excitement that comes with the creative and collaborative effort required to create and work within a 'third space', there is also a pragmatic outcome. That outcome is a strong sense of ownership over the resultant design and a great depth of understanding of it. The Hublink project shows that this sense of ownership, while not easy to achieve and sustain, leads to practical benefits. The research on Hublink shows how these benefits are seen in the later stages of implementation, when participants use their knowledge of the software to train their colleagues and deal positively with the inevitable questions, changes and frustrations that occur during the early stages of implementation.

Moreover, in the Hublink example, evidence shows that co-creation is intertwined with mutual learning to produce the capacity to sustain the use of the software in context well after the design phase is over. Through this evidence, we connect co-realisation to the final 'core perspective'; mutual learning.

3.1.3.3 Mutual Learning

> "The mutual learning implies that designers learn about the context from the users, but also that the users learn about the technical possibilities from the designers: the mutuality here makes Participatory Design different from other design methods".

> (Bratteteig et al. 2012 p.132)

The third core perspective or requirement of PD is mutual learning. In the PD model, mutual learning is key to achieving good design. Bridges must be built not only between domains of knowledge, but also between how different people think about those domains and how they approach problems and possible solutions. In PD therefore, Mutual learning is a goal for all team members. It is not simply a matter of communicating each other's knowledge about the design problem, it is a matter of how to build the capacity to work together.

We have seen in the previous sections how the design methods and techniques, developed within PD can therefore be seen as facilitators of shared experiences among the participants that create a flow of information and stimulate a collective creativity. The "Third Space" conceptualisation of PD methods in particular makes that function very explicit. In this section, we see how those methods are also facilitators of mutual learning. To do this, it is necessary to explore what we mean by learning in this context.

The learning that arises from shared experiences is not formal learning in the pedagogical sense. Instead, to understand mutual learning in this context is to see learning as experiential and social. Learning theories such as those of Kolb are often cited in PD. Kolb's experiential learning theory introduces a cyclical model that combines experience, reflection on action and additional abstract learning and thought that feed into a reflexive view of experience (Kolb 1983). Kolb's work echoes that of Donald Schön who defined the "Reflective Practitioner", a

concept that has been extremely influential in design research.   For Schön, professional development is achieved through a constant cycle of reflection and critical evaluation of ones own work. Through these cycles we gain incrementally greater understanding and insight that can be applied to future projects (Schön 1983; Schön 1990). Schön's insights have been applied to many professions and has had much attention in design.   The ideas about the reflective practitioner in art and design research was later developed by Steven Scrivener (Scrivener 2000) whose work is also discussed in the methodology section of this thesis.

Through these perspectives we are able to see how the social and material experiments that take place within PD, such as the collaborative evaluation of prototypes, can be learning experiences. However, Schön and Scrivener are primarily concerned with the learning and development of professionals. PD demands an extension of these ideas into a more inclusive domain that encompasses collective mutual learning for all participants. Moreover, learning in PD should support the overall aim of personal and social developments. Because of these ethical and political considerations, many researchers in PD find the theoretical underpinnings of mutual learning in PD in the writings of John Dewey relevant. For Dewey, not only does learning have its roots in experience, that learning is applied back into that experience to actively intervene in the world (Dewey 1910).   Learning therefore directly enables taking power and control and creates the potential for individuals to reshape their environment (Ehn 2008).

For PD, learning is experiential and has an ethical purpose for individuals. However, there is also a collective dimension. The work of Lave and Wenger (1991) is important here as it takes as its theme the ways that groups and communities take a role in informal learning. Lave and Wenger introduced the idea of "communities of practice" to describe how new people are inducted into professional practice communities, including their skills, language and world-view.   Lave and Wenger are social anthropologists and educational theorists respectively, and their work on Communities of Practice stemmed from observed experiences. Their observations were that new entrants to a field are introduced via "legitimate peripheral participation". That is, they undertake small , non-essential tasks first, which enable them to be present in a group and increase their familiarity with the social and practical nature of the work. As, through experience, their knowledge and understanding increases, participants move towards the centre of the activity, taking more and more control. In a community of practice, the explicit intention to learn is not significant.   Much more important is the coming together of people with a common purpose to achieve common goals; learning is not formal but emerges from the planning and realisation of shared tasks (Lave & Wenger 1991, Wenger 1998).

For PD, the Communities of Practice model of learning provides a useful theory that explains how the design and co-realisation activities developed by PD can lead to valuable forms of learning.   This binds co-realisation strongly together with mutual learning in a feedback loop in which learning underpins co-creation while the activities of co-creation build further experiential learning.   This model helps describe how a group of participants with diverse experiences become a team with the ability to work together, and how the knowledge of each other's work areas builds through the shared tasks and activities that comprise PD methods. Experiential learning and communities of practice show how such activities can be personally

transformative for individuals as they broaden and deepen their knowledge and are able to be increasingly creative.

In the Hublink project a number of learning outcomes were observed that became important for how the project progressed, feeding back into a deeper engagement with design and helping the project be sustainable. Indeed, it is proposed that Mutual Learning is a key connector between design and sustainability. The models of experiential and social learning from Lave and Wenger, with some roots in work by Kolb and Dewey connect the design methods we used with the learning outcomes we observed. The Communities of Practice model of learning also connects together threads of this research as it has also been applied to descriptions of how open source communities function. (eg Hill 2011, Ducheneaut 2005, Scacchi 2005). We return to this in the chapter of this review on FLOSS. Communities of Practice therefore provides another theme connecting PD and FLOSS.

Jean Lave is known for her seminal work not only on Communities of Practice. Her observational work on the situated nature of learning and the improvisational and the creative character of human problem-solving she documents has also been extremely influential for PD (for example, Lave 1998). In the final section of this part of my review, the importance of 'situated action', which can be seen as an extension of Lave's observations about learning into the field of design are explored, accompanied by models of responsibility and accountability coming from feminist philosophy. In the previous section we have noted the influence of social anthropology in shaping PD and broadening its concerns. In particular, we have seen how the idea of learning as experiential and unique to a context has helped create a model of learning that integrates with design. We have also noted the contribution to PD of perspectives from STS and feminism, which have questioned the notion of knowledge as singular by drawing on the work of philosophers of science such as Donna Haraway. Through these contributions, PD has come to be defined as a 'situated design' practice and,through being based on the 'partial knowledge' of participants with different perspectives and approaches, inherently collaborative. Through these influences, an ethics of PD has also been refined, based on the idea of 'located accountabilities'. It is these features of being situated and located that we will explore in the next section.

3.1.3.4 Situated Action, Located Accountabilities and Artful Integration

Anthropologist and HCI researcher Lucy Suchman made a seminal intervention into the field as a writer and practitioner, bringing together feminism and Science and Technology Studies (STS) with practice in information system design. Suchman worked as an anthropologist at Xerox Parc Research Center during the 1980s. In 1987 she published Plans and Situated Actions: The Problem of Human-machine Communication (1987). This book provided an early and important voice challenging the cognitive science based approach to HCI, adding detail, theoretical perspectives and methods that challenged engineers to think completely differently about the systems they designed. Suchman's was a bold voice who described herself as working with 'a small network of allies' across different disciplines and in different countries. The position of those allies is an explicitly critical one. Taking a retrospective view of this network she says:

"What bound us together were a series of dissatisfactions regarding the regime within which we were asked to work, and a set of partial but related imaginings of how things might be different"

(Suchman 2002b p.3)

Suchman's idea of Situated Action is firmly rooted in observable experience, and observation of behaviour is valued above any other forms of data gathering. In common with Lave and Wenger, human behaviour is seen as inseparable from its context, by which we mean its environment or 'setting' and the artefacts involved. The wider work of Jean Lave, with its appreciation of the 'improvisational' character of human behaviour inspires Situated Action. For Lave, activities are seen as unique responses to an un-repeatable set of problems and circumstances. Suchman took this challenging view into the heart of technology production at Xerox Parc. Creating technical solutions that match this analysis are challenging, but Suchman suggests that plans should be seen as "resources for action", rather than ways to determine action (Suchman 1986).

Suchman also poses questions about the "cultural practices" in technology development and use.(Suchman 2002a) . She does this by citing the feminist contributions to STS that challenge the idea of singular objectivity and connecting them to design by pointing out that our technologies are the results of these scientific conventions. As an alternative, Suchman argues that we should always locate our work with technology, analysing our position in the process and our contributions within or across boundaries which may be local to our group of collaborators, or stretch globally to encompass all the networks of industry and labour that supply our technologies. Coming with this challenge to locate our perspective comes the imperative to take responsibility or be accountable for the knowledge we have and how we deploy it. This is the concept of "located accountability" (Suchman 2002a).

Expressing her work as single concept, Suchman put forward the idea of "Artful Integration". This concept acts as a counterpoint to the tendency in wider culture to attribute all good design to the personal talents of individual designers, or specially innovative studios or companies. Instead, Artful integration recognises that effective designs are more likely to be a unique re-combination of existing things and networks of people that have been deployed into a particular context with insight and sensitivity (Suchman 2002b).   The PD community enthusiastically embraced this notion. Artful Integration was the theme of the 2004 Participatory Design conference, during which an "Artful Integrators" award was also launched that is now presented at each PDC . Later in this review we see how this concept has inspired the idea of infrastructuring in the PD context.

As a situated practice, PD practitioners acknowledge the uniqueness of every design project and its participants. The idea of a situated practice also enables effective design outputs to be

measured in modest terms. Just as there is no universal design context, PD outputs do not claim universal applicability. As the result of partial knowledge and unique constraints, effective designs are most often modest steps that are new or a re-configuration of existing resources, artefacts and social relations and this should be more widely recognised.

In this section I have covered the themes of situated action, located accountabilities and artful integration quite briefly. They are based on highly theoretical concepts that have been explored extensively in feminism, cultural studies and philosophy of science. For me, PD is important because it is able to find an expression of these ideas through practice and, moreover, use them to inform the creation of technological tools that people actually make use of and can control. They are also useful in enabling practical projects to avoid having to make grandiose claims in order to be valued within their own community.

These concepts of situatedness and locatedness are very important for understanding the Hublink project. They set the scope and relevance of the research, define what is valuable in the research and where its findings are applicable, and how responsibilities should be recognised, shared and taken forward. They have also influenced the format and writing style of the project description. These issues have both informed practice, and overlap with the research methodology of this study. Therefore they are also discussed in the chapter on methodology. These topics are important for two reasons. Firstly because they further extend the subject of this review which is to explore the field of PD and its applicability to the community context and FLOSS. Secondly, because situated practice creates a thread that links between all parts of this research project; the review, methodology and the project description, its style of presentation and the claims made.

3.2 After Design: Infrastructuring, Appropriation And Tailorability

In the previous section we have seen that Participatory Design creates a distinctive starting point for a production project that enshrines the aims of having a say, mutual learning and co-realisation. Moreover, the decision to use PD goes beyond wanting to align politics and values for political or ethical reasons. PD has a pragmatic value, especially in the community sector characterised by constraints on resources, intending that the result will better meet the needs of people and organisations if users are included (Carroll & Rosson 2007).

But what of the leap from design into production and ongoing use? Within PD literature, it is widely acknowledged that design is unfinished and incomplete and the line between design and implementation is blurred . This is a reality almost all software development practitioners recognise intuitively. In literature related to PD, this theme has been explored by authors including Henderson and Kyng (1992), Nardi (1993), Fischer (2003; 2004) , Fischer and Giaccrdi (2008), Fischer et. al. (Fischer et al. 2004), Wulf, Pipek and Stevens (2009), Simonsen and Hertzum (2008) Bjogvinsson et. al. (2012). This work is returned to later in this section.

In commercial models of development, the blurring of the design and use stages is highly undesirable, leading to perceived difficulties related to cost and scheduling and user satisfaction. However, for PD practitioners and their allies such as those mentioned above, these emergent and late coming requirements, though challenging in practice, are embraced. For many PD practitioners, these are opportunities to develop approaches and practices that complement rather than try to eliminate the challenges of unpredictability and change.

The observation that design continues into use has been discussed using the constructs of "design in use" including (Henderson & Kyng 1992), Pipek & Wulf 2009) or "design after design" ,including (Bjögvinsson et al. 2012, Bratteteig et al. 2012). Indeed PD pioneer Pelle Ehn, writing with Bjogvinsson and Hillgren, has suggested that there are two different approaches to PD in design; one is to use PD to envision "use before use", and therefore aim to create a complete design. The other is to design for "design after design" – that is to design for future customisability after the design stage (Bjögvinsson et al. 2012).

These approaches reflect two separate but related problems. One is the realisation that any design process is incomplete and unable to fully capture and reflect all the complexities that emerge during use. The second problem is the inevitability that changes will be required after design to keep the system relevant and useful to an ever-evolving working context. This point is well put by, for instance, Simonsen and Hertzum (2008). This second problem is therefore a problem of sustainability, rather than a shortcoming or limitation of what is possible during the design process.

In addition, sustainability beyond the design phase must also take into account additional tasks needed to ensure a system's continuing use, for example; facilitating adoption by new users, producing documentation and ensuring ongoing technical robustness.   This work is varied, stretching across social and technical concerns. The tasks are essential, for instance, managing maintenance including hosting and security and responding to changes in staffing which brings challenges around training and adoption.   Especially when working within community groups, these longer term activities need to share values and accommodate the same constraints as the design process but need to do so over a broader range of activities over a longer time-frame. For all these reasons they pose a significant challenge.

This section looks at theories of how projects transition into or are supported in use. The concept of "infrastructuring" is discussed at relative length as it is a key part of the argument of this thesis. The 'infrastructuring' concept leads into a more focussed discussion of 'tailorability' and 'appropriation' which describe long-term processes by which users can be seen to interact creatively with their tools producing local customisations and a strong sense of ownership.   We extend these ideas in then looking at 'end user development' (EUD), and meta-design. The Boundary Object, as we shall see, is an additional theoretical concept originating in science and technology studies, that at least in part offers a theory of how 'tailorability' may take place and how infrastructures can be built that are both specific to context and re-usable in different situations.

All of the concepts covered in this part of the review can be found in my observations during the work on Hublink. They have provided accurate analysis of my observations from practice. They have been insightful to read and illuminating to apply. My contribution, from the evidence in my project, is to observe how the human capacity to fulfil these tasks is related to the mutual learning outcomes of PD. Complementary to this, I argue that the contribution of FLOSS practices and artefacts can be seen within the frame of infrastructuring, contributing a technical element that compliments this human capacity. It is therefore via infrastructuring that the key thread of this thesis; the linkage of PD and FLOSS to sustainability, is completed.

3.2.1 From Infrastructure to Infrastructuring

Infrastructures are the taken-for-granted systems that support our everyday activities. Examples include the water, railway or electricity systems. Susan Star observes that while infrastructure by definition is 'ready to hand' for most people, for others it becomes visible or is their foreground concern. Examples she give include a wheelchair user for whom a flight of stairs are a barrier rather than a barely noticed part of the environment, or the railway worker for whom the rails are the main concern or 'topic' for their everyday life (1999). It is with these observations that Star begins to build a picture of infrastructure that has social, technical and relational contingencies and dimensions.

Star was a social researcher who took her interests and skills deeply into Science and Technology Studies (STS). She worked with key researchers in the field including Bruno Latour and extended both an observational, ethnographic approach and incisive theorisation based on that approach to how computer and information systems were used, especially in scientific research. Like Latour, close observation of actual work practice in the laboratory and an ability to theorise as to how the meanings and effects of everyday work practice extends into the realms of the social and political were key features of her work. The pairing of critical and ethnographic work in information systems converged with several key PD practitioners. Star published with several other researchers whose work has been important in PD, especially Americans who were influenced by STS such as Lucy Suchman and Janette Blomberg. This work that privileges ethnography as an approach or method is central to the field of "Computer Supported Cooperative Work (CSCW), which shares much ground with PD in terms of methods, approaches and key practitioners.

Susan Star and Karen Ruhleder published a key paper;   "Steps toward an Ecology of Infrastructure: Design and Access for Large Information Spaces" in 1996. This paper took as its subject an effort to build an information sharing network for scientists working on a particular species of microscopic nematode worm, c.elegens.   Significantly, the project took place during the early 1990s: a distinctive moment in time when the internet was quite established as a research network but was at the cusp of the introduction of the world wide web as the predominant protocol for sharing information. Conventions in how technology could be used by dispersed teams were very much in flux at that moment and though much has changed since, this study has maintained its relevance. Its proposition that the relatively limited and small-

scale artefact of an information system could be understood as an infrastructure has been an important contribution for PD and related areas.

In this study, Star and Ruhduler observe and analyse an information system used by around 1400 scientists in around 120 different laboratories around the world. The information system was intended to share and publish information about c.elegens that, because of its special characteristics, had been selected for special study by biologists. As an indication of its importance, in the few years following the study in 1998, c.elegens became the first organism to have its full genome sequenced. It was against this background of additional attention and institutional pressure on an existing research community that the study was undertaken.

The authors start this very specific study with some very general observations. They point out the necessity for technologies used by dispersed groups to have two opposing characteristics. These technologies inevitably impose rigidities and must accord with specific rules but, nevertheless it is equally inevitable that local adaptations will arise that respond to local conditions. These local adaptations – essential if a system is to be adopted at all - must be negotiated between all the users if the system is to work. With this observation they point to the importance of standards, but with a caveat that standards themselves are contestable, saying "one person's standard is in fact another's chaos" (Star & Ruhleder 1996 p.3). Following on from this observation, the common conception of infrastructure as something that is fixed and invisible is questioned. Instead, Star and Ruhleder point out that infrastructures, like tools, come into being only through use, and in a specific situation. In conclusion, Star and Ruhduler propose that Information Systems become infrastructure in context and under specific conditions of use, and that far from being a fixed array of objects, these systems are in a continuous exchange of cause and effect that alters both usage and infrastructure (Star & Ruhleder 1996)

This augment leads to a picture of infrastructure as a powerful development in itself, emerging from a resolution of conflicting needs and providing a connected and re-usable support structure for local practices. Nine characteristics or "dimensions" of infrastructure are identified in the paper [1]. Some of these dimensions relate to people and their practices, some are related to the

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1   The eight dimensions of infrastructure (Star & Ruhleder 1996; Neumann et al. 1996)

- "Embeddedness". This refers to infrastructures as "sunk into or inside of" other systems including social structures and technologies.
- "Transparency." Infrastructure should support tasks seamlessly and be re-usable across related tasks.
- "Reach or scope" Infrastructure reaches beyond a single-use or single context
- "Learned as part of membership" People learn about the system by being intimately involved with it. New participants must acquire that knowledge to become part of its communities of practice.
- "Links with conventions of practice". Infrastructure systems both shape and are shaped by everyday practice in the domain the system supports.
- "Embodiment of standards". The quality of transparency is achieved through sharing common conventions with other tools and systems via. Standards.
- "Built on an installed base". Infrastructure is not built on a clean slate. It "wrestles with the inertia of the installed base" , that is it inherits characteristics of existing work practices.
- "Becomes visible upon breakdown" The quality of transparency is disrupted when the system does not work.

visibility of the system to its users and some refer to characteristics that make the system useful and usable. These nine characteristics combine social and technical features and emphasise the situated nature of how technology is embedded into everyday practices.

Both the approach and results of Star and Ruhleder's have strong resonances with the Hublink project in terms of its observations and analysis of infrastructure. Moreover, it is extremely useful in showing how observing, describing and analysing a single case can be used to build theory and open up more general questions. The nine features of an infrastructure provide a good description of how a project like Hublink progresses from being a central object of design effort to and everyday tool embedded into daily work practice without focus of attention - unless something goes wrong. Star also takes on the themes of adoption and learning as a central theme of infrastructure, as well as the theme of improvised adaptation in different contexts – both echoing the models of situated action and communities of practice that, as we have seen, have attracted attention in theorising around PD. From a more general perspective, these nine dimensions of infrastructure provide a strong link with the foundational approaches of PD, do not address any kind of design practice. Nevertheless the article's conclusion points towards creative processes; stating that:

> The competing requirements of openness and malleability, coupled with structure and navigability, create a fascinating design challenge -- even a new science.

> (Star & Ruhleder 1996 p32)

The themes have indeed gone on to have a long life among researchers as we shall see, and in particular found connection to the field of computer supported cooperative work (CSCW), a research area within HCI which seeks to understand the use of computers for collaboration in holistic ways that unite social and computer sciences. Star herself went on to develop this work, first suggesting the verb 'infrastructuring' in the article "how to infrastructure" written with Geoffrey Bowker published in 2002. The uptake of the infrastructuring concept is expanded in the next section.

3.2.2 Infrastructuring and PD

As we have seen, the social nature and contextually contingent dimensions of information infrastructures described by Star and her collaborators connect with many of the concerns of PD. Most usefully, the concept of infrastructuring offers a framework that shares many concerns with PD though it is engaged with longer term activities, reaching into the period after design.

Helena Karasti extends the idea of information infrastructures more deeply into PD through her research with Anna-Liisa Syrjänen on two cases of community sustained information systems. They mobilise the term 'infrastructuring' for their study reflecting the need for a more process orientated and temporally extended understanding of how participation supports ongoing

endeavours. This step is made through the observation and analysis of projects that did not use PD in their production processes but which depend on community participation for ongoing evolution, development and support (Karasti & Syrjänen 2004).

Karasti and Syrjanen unite Star's analysis of infrastructure with Suchman's concept of Artful Integration discussed earlier in this review to suggest the term "Artful Infrastructuring". Artful Integration suggests that design artefacts might be understood as the materialisation of many disparate forces, perspectives and relations. Artful Infrastructuring therefore suggests that the more ongoing endeavour of infrastructuring could likewise be seen as the whole set of social and technical collection of knowledges, social conditions and technical artefacts required to build an infrastructure. In a move that is relevant to this research project, they also foreground the importance of shared values in the community projects that they observe. (Karasti & Syrjänen 2004)

In Karasti's more recent review of how infrastructuring interfaces with PD (2014), a number of settings where infrastructuring may take place are identified.   Firstly Karasti refers to infrastructuring in the workplace, a theme that has been expanded by Wolf and Pipek (2009), and covered in more detail in the following section on tailorability. Secondly she refers to infrastructuring in communities, citing studies such as DiSalvo et al (2012) that are important precisely because they take PD out of the strict confines of the workplace and identify new challenges for working in un-institutionalised settings.   Karasti expands this concern for communities by mentioning the work of Ehn and collaborators who are working towards a multifaceted and open ended approach to design. In this work, Ehn et al suggest the notion of 'design Things'[2] as an expression of the assemblage of actors and objects needed to approach social problems (Ehn 2008) . Finally, in a step fairly rare for PD literature but important for this study, the 'commons' is directly addressed. Karasti refers to work including that by researchers including Anttila and Botero et al, and Bjorgvinsson, who suggest that an infrastructuring model might be a suitable description and set of tools for developing and sustaining the "information commons" (Marttila et al. 2013). Infrastructuring, therefore, helps us see how the values and experiences of PD might extend PD into new areas such as supporting community activism or enabling 'the commons' to function as a truly shared resource (Karasti 2014)

In summary, Karasti argues the infrastructuring provides an important route towards revitalising and extending PD into existing and new areas of theory and practice. For researching and analysing the Hublink project, the concept of infrastructuring has provided a conceptual framework to understand how longer-term projects work and begin to point the way towards how we might lay the right preconditions for a system to extend beyond its design phase.

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2   'design Things' is a proposition from Bjögvinsson, Ehn and Hillgren for addressing the field of 'social innovation'. In addressing social problems through design, these writers suggest moving away from designed objects and towards the construction of more fluid and participatory 'socio-material assemblies' that are better able to deal with contradiction and controversy. In this respect the concept is inspired by the work of Bruno Latour who suggests a dissolution of the boundary between objects and social phenomena (Bjögvinsson et al. 2012).

3.2.3 Appropriation and Tailorability

> "The challenge of design is not a matter of getting rid of the emergent, but rather of including it and making it an opportunity for more creative and more adequate solutions to problems."

> (Giaccardi & Fischer 2008 p.19)

In the previous section we mention that the idea of Infrastructuring, as developed within PD, suggests that a condition of sustainability is that it includes the ability for continuous customisation. This topic is taken up in more detail and with specific reference to Information Systems by Wolf and Pipek who link infrastructuring to tailorability, and thereon to the broader fields of end user development (EUD) and meta design. These connecting steps are key to my own research and it is here that we arrive at a framework for understanding and describing the results of my own project.

In their paper Infrastructuring: Toward An Integrated Perspective On The Design And Use Of Information Technology, Wolf and Pipek examine the analysis and description of infrastructure that has led to new idea of infrastructuring. They then apply the findings directly to design and use it to build a methodology for work-based contexts. Wulf and Pipek set the scene by describing the complexity and layered nature of how IT is installed and used in the work environment. The problem they observe is that this complexity renders many requirements of a system invisible and impenetrable to understanding by the users. This variability leads to the inevitability that designs will be initially inadequate and will require iterative work to improve them. Wulf and Pipek suggest that if collaborative information systems are seen as flexible infrastructures, then users will inevitably want to re-shape them during use (Pipek & Wulf 2009).

This drive towards tailorability involved a blurring of traditional roles of user and developer but also, in the time-based schedule of development, leads to problems. Wulf and Pipek humorously point to a real and practical problem of time and priority, saying that:

> "In a participatory IT design process, the designers usually decide that it is "design time," while the user has problems allocating time for an additional task within the daily work routine and explaining his expectations of unknown new work practices using new technology. On the other hand, when a certain technological improvement occurs to users during use, it is not necessarily "design time" for professional designers"

> (Pipek & Wulf 2009 p.458) .

The point they make is that design and use inevitably overlap in time and effort, that users and developers are not looking closely at the application at the same time, and that therefore the sequence of design and use is fluid leading to all kinds of organisational problems. These

problems lead logically to a question of whether the end users might themselves be better placed to customise applications for themselves.

A shift towards users customising for themselves engenders a far-reaching blurring of roles and the redefinition of design practices. Wulf and Pikek suggest that users who gain specific skills in tailoring a specific application can be seen as part of the infrastructure and contribute a huge amount to the success or failure of a system. Wulf and Pipek paint a picture of a user's transition between roles, suggesting that key moments where this transition becomes evident is when dealing either with breakdown (a clear reference to one of Star and Rhudler's nine dimensions of infrastructure), or when a local resolution is created for a problem that was creating a barrier for other users:

> "We consider these the two defining moments for the infrastructurer when she crosses the border from using to reflecting/modifying technology. This is the point of infrastructure when the routines of performing work meet the technology development activities of professional designers".
>
> (Pipek & Wulf 2009 p.458)

Users' desire to customise applications and better match them to their needs is also enacted through appropriation. While tailorability refers to customisations that have been planned and made possible in a design, appropriation refers to the largely hidden but highly creative process in which users find unintended functions or workarounds for designed-in features to meet their needs or desires. For engineers and designers, it is tempting to see appropriation negatively as an irritation or a flaw. However, a more social perspective suggests that the appropriation activities of users should be seen as a creative response to real-world problems and an opportunity for infrastructure improvement. Additionally, Carroll and Rosson among others have noted that appropriation is a way for people to achieve a sense of connection with their technologies; they note that people reshape technology-in-use to accommodate their practices and values, and in doing so, they increasingly come to feel ownership of the technology, (Carroll & Rosson 2007). Appropriation can therefore be seen as a kind of bottom-up empowerment of users in relation to their technologies.

Having pointed out that tailorability and appropriation are key to sustainability, Wulf and Pipek go on to specify the technological support needed to enable tailorability. They offer interesting ideas about how systems and interface design could improve the potential for users to tailor by giving the user more information on the system's functioning, for instance via greatly expanded help texts and labelling. In summary, Wolf and Pipek provide a powerful argument that tailorability is a key element in sustainability. It then follows that a set of affordances to enable tailorability should be designed in to both technical artefacts and the social practices around them. These affordances would then be key elements of infrastructuring.

The connection between tailorability and infrastructuring are also related to what Karasti terms 'generativity'. Karasti describes generativity as the ability that information infrastructures may

have to allow the creation of "new content and applications without additional assistance from the system's original designers" (Karasti 2014 p.141). We will discuss in a later section of this review how some writers such as Zittrain have pointed out that that this quality of generativity is deeply embedded in the principles and outputs of FLOSS communities (Zittrain 2008). Thus we can propose that generativity connects FLOSS with infrastructuring

The Hublink project clearly shows both the need and desire for user customisation after the design process. It is only the ability of both designers and users to continue to tailor the application during the whole of its life cycle that has made it continue to be fit for purpose over a period of 2 years. Evidence in the Hublink research shows that this continuous adaptation has occurred through both tailorability and appropriation. Tailorability in large part is provided by the design of the FLOSS based development framework Drupal whose underlying philosophy has a strong and explicit emphasis on enabling user customisation.   However, just as PD teaches us that a seat at a table is not the same as having an effective say, providing the technical capability for users to tailor is not the same as enabling tailorability. In the case of Hublink, the key observation is how the PD design process, via mutual learning, facilitates both tailorability as well as a form of empowered appropriation.

3.2.4 Meta-Design and End User Development

The proposal that end user development may be a key route to sustainability, and that it might be seen in the context of 'infrastructure' is also explored at length in a discussion related to PD under the banner of meta-design. Meta-design as a whole is a diverse field that looks for methodologies for wider collaboration and the opening up of new forms of creativity. Metadesign looks to expanding the "scope of design" and design practice to "cope with the complexity of natural human interaction made tangible by technology" (Giaccardi 2005 p.344).

Literature in meta-design shows strong connections to the early days of interactive arts in the 1980s with its utopian ambitions for creative user involvement and continues to encompass theorising forms of user or audience participation in the cultural and creative field.   Meanwhile, within the field of computer science, the banner of meta-design has been used by some writers, notably Gerhard Fischer, as a way of further highlighting the need for tailorability after design.

Meta-design, like PD, emphasises the need for co-creation to enable the production of effective tools. Within the meta-design perspective, co-creation is wholly facilitated through the design of technological tools for tailorability. It is through such tools that users input creatively and the blurring of users' and designers' roles take place.   Fisher says:

> "A necessary, although not sufficient condition for meta-design is that software systems include advanced features permitting users in creating complex customizations and extensions".

(Fischer 2003 p.2)

Meta design is therefore a more technologically led approach than PD although there is also a recognition that various forms of human centred learning is required to fully enable users to customise. Meta-design also lacks the concern for ethics and values found in PD. However, the strength of the meta-design perspective is its focus on sustaining of "emergence, evolution and adaptation" (Giaccardi 2005 p.13). Echoing the distinction by Ehn and others between 'design after design' or 'design in use', Fischer distinguishes 'use time' from 'design time'. For Fischer, it is empowering the user during use time that is most important (Fischer 2003). During design time, rather than attempting to use participation to get as close as possible to a finished design, the emphasis of effort should be on creating incomplete designs. These incomplete designs should be complemented by the development of tools that are explicitly created to allow the user to engage creatively with the system and perform necessary steps for completion and ongoing adaptation to changing needs. (Giaccardi & Fischer 2008)

The work by Wulf and Pipek and also Fisher, is based on the extremely important observation that adaptation is always required throughout the use of a system, and that fact should not be resisted or seen as a flaw in initial design. While both note the importance of tailorability and the potential value of appropriation, meta-design puts these at the centre of the design project. Both also observe that the concept of infrastructuring, as multi layered and consisting of both social and technical elements is crucial to support ongoing adaptations to changing circumstances and needs.

Comparing the infrastructuring perspective to PD, I do not see that meta-design "transcends" PD as suggested by Giaccardi and Fischer (2003 p.2), Rather that it has a different emphasis and can be seen as complementary. With its observation of the inevitable incompleteness of design solutions, meta-design pinpoints an important but uncomfortable truth about software development. Meta-design contributes by both alerting us to the widespread nature of this problem of the need for changes after design and encouraging us to embrace it as an opportunity. The need for tailorability is also increasingly recognised within PD especially though its embrace of the notion of infrastructuring and its interest in bottom-up empowerment. The concept of infrastructuring that emerges from PD is one that is broader in scope, and more critically grounded than meta-design. Its recognition of the diversity of infrastructure, its social elements, located contingencies and power relationships make its message about tailorability less straightforwardly put but fully grounded in practice and the observed complexity of situations in which IT systems are deployed. Within a community setting, this stronger attention to politics is significant so the infrastructuring perspective is closer to describing the complexity of deploying and maintaining an IT system in this context, and the broad range of ever-changing dependencies – most of them non-technical - that are an ongoing challenge.

Despite their differences, both meta-design and the study of tailorability within PD lead to the same next step of proposing forms of 'end user development' (EUD). EUD is focussed on addressing exactly this issue raised by both meta-design and the infrastructuring perspective of PD; how best to create tools that allow people who are not developers to take on at least some development tasks so as to be able to tailor their own systems. EUD is an established perspective in computer science which studies and facilitates a broad range of methods by which users who are not developers may take on programming-like tasks. The field is surveyed

in 2006 in the book End User Development (Lieberman et al. 2006), which defined EUD as follows:

> "a set of methods, techniques, and tools that allow users of software systems, who are acting as non-professional software developers, at some point to create, modify, or extend a software artifact".

> (Lieberman et al. 2006 p.18)

The most basic example of EUD is the spreadsheet in which the ability of users to write formulas that process data has been well studied as form of EUD (Nardi 1993). Another example given in the literature is the writing of custom email filters. These, as configuration files, can be seen as an activity in between programming and customisation. Some see EUD encompassing visual programming environments such as Scratch that are designed for children to learn programming concepts while building fun and creative games from 'blocks' of pre-written code, manipulated via an easy drag-and-drop interface. Aside from being notoriously difficult to design for, the major critique of EUD is that it leads to messy, undocumented and potentially insecure or inconsistent applications or data (Lieberman et al. 2006). Put in other words, the worry is that without the rigour of software engineers, too much freedom for users can be a dangerous thing.

However on the positive side, meta-design and the infrastructuring in PD connect with EUD by suggesting that EUD can be used by people to shape and refine their tools of work, and that this, in turn, is linked to sustainability. Tailorability, with appropriation, give users a stronger sense of ownership over and connection to their tools, and enables systems to adapt to changes in the external operating environment. Perhaps there is a balance of risk in EUD to be worked out. On the one hand a system without EUD may quickly cease to be relevant enough to work practice to be usable or be too expensive to adapt to new needs. On the other, there are the risks of bad practice, as detailed above, should the parameters of customisation be set too widely.

PD is focussed on the ethics and personal/social development that might come from 'design in use', whereas meta-design is more focussed on expanding creativity. EUD takes a practical approach that is linked to effective work and sustainability through flexibility. However, all seem to be missing a key element. This element is learning; how the capacity of these end users is increased to encompass the job of end-user tailoring. In discussions about EUD a question inevitably arises; how to locate or perhaps even create these local users with the expertise to perform local customisations who take such a key role. These expert users must be individuals with both domain knowledge and the right kind of technical knowledge or aptitude to tailor. Nardi and Gantt discuss this in relation to CAD users in their study from 1992. They identify a role in the workplace for those who can both understand the domain and tailor applications for themselves and others. They call this role "gardeners", However, they highlight how difficult is is to find people who can do this, saying:

> "A person who is technically skilled but uninterested in intensive interpersonal interaction may not have much of a green thumb when it comes to helping other users"

> (Gantt & Nardi 1992 p.113)

The idea of a special kind of user has gained some traction in studies of innovation. Some writers, for instance Von Hippel, emphasise the importance of such users to the development of new products, proposing that 'lead users' should be identified and explicitly brought into the design process (Hippel 1988). Others are more interested in how 'power users' emerge informally from user groups and then become key bridges between developers and users (for example Baskerville et al. 2000) . Meanwhile, the 'gardeners' described in Nardi's study are valued for their combination of technical and interpersonal skills (Gantt & Nardi 1992).

Within PD an ongoing and concrete example of how this kind of bridging role can be well defined and benefit both local use and wider development is in the work of 'implementation mediators' within the Health Information Systems Programme (HISP) project. The HISP project is a long running and well-documented PD project that works in partnership to develop a health information system that is responsive to the needs of communities and healthcare workers in the global South. The project is long running and geographically distributed but must fit in to a wide range of different local contexts (Braa et al. 2012) . To help address some of the challenges in both design and use, HISP makes use of "implementation mediators". Implementation mediators work in the field in different countries; they have technical skills and are domain experts. They make sure HISP is working well in the local context and is tailored to local needs. But by also feeding information and requests to developers, their role also connects the local use context to the global production effort, as well as connecting technical and domain experts (Shidende & Mörtberg 2014) . Within a PD context, as Shidende and Mortberg argue, the implementation mediators must also have skills in facilitating wider participation in the communities they work in (2014).

It is certainly the experience documented in this project that the emergence of requirements and the need for tailorability after design is always present. This need is also something I have observed in work outside of this project that I have done as a web developer in other commercial and not-for-profit contexts. In undertaking this project, the team did not explicitly plan for EUD, though we knew that our FLOSS-based system could create opportunities for it. We had no way of knowing if the community organisation would have the capacity or the interest to tailor for themselves. In the Hublink project, the desire for it emerged, and to some extent, it was possible to enable it because of the framework we were using. In the project description, we see that evidence points to both the desire and capacity for end-user development arising via the mutual learning outcomes of PD.

The project description provides evidence that tailorability has been key to the sustainability of this project, especially due to the changing external circumstances that led to new requirements well after the design phase. Without the ability to tailor, the application would soon have become unusable. The significance of these environmental changes are illustrated in the last part of the project description in which I present empirical evidence that shows the pattern of different kinds of tasks. Evidence shows that, out of all the team members, those who had participated in the design process were the most keen and most able to make use of these tailoring capabilities.

Infrastructuring, therefore, allows us to link tailorability, FLOSS and the mutual learning outcomes of PD as parts of the human/social side of this infrastructure, and secondly, that open source software can provide a key technical element. Meanwhile, we will see later in this review how the specific characteristics of FLOSS practices and products make them especially suitable for deployment in an infrastructuring context.

3.2.5 Standards and the Boundary Object

We have seen that the idea of infrastructuring has been influenced by writers such as Star whose primary discipline is Science and Technology Studies (STS) and whose methods were primarily ethnographic, privileging the observation of people's practices in specific situations. We have seen that the theoretical notion of infrastructuring that has stemmed from this observational work has come to complement a number of the social and technical concerns found in PD. The insights from the infrastructuring perspective have been influential in PD. For instance, Pelle Ehn, a pioneer of Nordic PD, reflects that perhaps PD itself could be seen more like infrastructuring (2008). We have seen that this reflection is expressed in his suggestion of design 'Things' influenced by, as Star's pioneering work was, the work of Bruno Latours idea of a 'socio-material assemblies' (Bjögvinsson et al. 2012).

However, even within situated design practices, common ground needs to be established with a wider arena. From an infrastrcture perspective, the idea that technologies should interoperate is deeply seated within engineering and is especially prominent in information technologies. From a usability perspective, designers well know the importance of adhering to at least some familiar conventions of interface design that are common between applications. The internet itself is an inter-operable 'network of networks', and setting, developing and maintaining the technical standards that allow for this is a site of both exemplary collaboration and great contestation and power struggle. For example, Carl Malamud's remarkable book Exploring The Internet is an engaging story of the complex process and bitter struggles over standards that has made interoperability on a global scale possible (Malamud 1992). The success of FLOSS itself would not be possible without wide ranging technical standards that allow softwares to work together within and between projects.

As we have noted, Star and Ruhleder's main intervention, further developed by Karasti and others, was to bring the concept of infrastructures into endeavours that are small scale and which include the application and human layers in the concept of infrastructure. Given the importance of standards for infrastructures, we may ask what comprises a 'standard' in this smaller more inclusive notion of infrastructure. While a user experience designer may find this a straightforward question and respond by pointing towards design or interface conventions, such as the 'back button', we are looking at a social and technical system holistically. We have greater aspirations, our ambitions are stretching well beyond usability into tailorability.

For this we may look toward the 'boundary object', which provides a theoretical model that is much broader and less instrumental than a 'standard' and which adds depth to our understanding of how tailorability and appropriation may take place within the 'shared information space' (Bannon & Bødker 1997) of an information system.

The boundary object has its origins in the work of Star and James Griesemer (1989). In this work, the boundary object is a theoretical construct that helps us understand how artefacts or ideas are concrete enough to be common between people, places and practices while also being fluid enough to be used and created in different ways. The seminal example of the boundary object is a map. Star uses this example to explain the concept in a later, retrospective paper saying:

> "A road map may point the way to a campground for one group, a place for recreation. For another group, this ''same'' map may follow a series of geological sites of importance, or animal habitats, for scientists. Such maps may resemble each other, overlap, and even seem indistinguishable to an outsider's eye. Their difference depends on the use and interpretation of the object. One group's pleasant camping spot is another's source of data about speciation".
>
> (Star 2010 p.602)

Star calls this fluid quality in use 'interpretive flexibility' (Star 2010).

Bannon and Bodker bring the notion of the boundary object to software systems design by suggesting the idea that the 'common information spaces' created by information systems could be seen in some senses as boundary objects (1997). The idea of the boundary object has also been taken up by a number of researchers for a range of purposes. Pipek, Stevens and Wulf use it to add weight to their argument for designing for appropriation and tailorability, suggesting that the system itself could be seen as a boundary object (2009). Pelle Ehn suggests that many of the materials and practices of PD could be seen as boundary objects in themselves, being contestable and interpretable artefacts that provoke communication and the exchange of information (2008). This view of the design process as a set of mediations by boundary objects is echoed by Muller and Druin who apply it to other HCD techniques, making specific reference to the use of photographs to stimulate discussion (2003) . For Fisher, in his analysis of how creativity is facilitated in collaborative groups, boundary objects are any artefacts that 'allow different knowledge systems to communicate' (2004). Karasti and Syrjänen, in their re-evaluation of the concept of infrastructuring suggest that a code module while in test status and being evaluated by expert users could be seen to be a boundary object 2004) In further work, Wulf and Pipek suggest that the concept of infrastructuring is itself a boundary object that may be useful in bridging the gaps between creative and more structured approaches to software systems design (2009).

Despite this disparate use, the concept of the boundary object is important for this review for three reasons: Firstly, it is a concept that is able to connect the critical work of STS with the practical challenges faced by system designers and thereby provide a rationale for some key

design methods within the terms of reference of STS. Secondly, the Boundary Object is a way of understanding the key role and contested nature of standards and interoperability and is able to extend this mostly technical concept to social concerns. Thirdly, it deepens our understanding of the ideas of appropriation and tailorability, key concepts for this research.

In this research, the key findings can be seen to involve several interpretations of the boundary object. The design methods, especially the use of prototypes and scenarios, did indeed act as contact points and channels of communication between the different participants with their varied backgrounds and different ways to approach description and understanding. Evidence also shows that participants have undertaken both appropriation and tailorability.

3.2.6 Infrastructuring and Sustainability

As we have seen, for a number of writers in PD such as Karasti and Wolf and Pipek, infrastructuring is explicitly linked to sustainability. For them, it is the constellation of material and social resources that provide the support essential for the long-term maintenance and relevance of a software project. Other researchers in PD reach a similar conclusion using different terms of reference. Some researchers have raised this concern by asking the questions about how a project ends. What happens to a research project when the researcher exits? or when a project comes to the end of its institutional support?

Iversen and Dindler (2014) point out that few studies in PD have looked at the life of projects after their 'end'. While acknowledging the implicit support for sustainability in the mutual learning outcomes of PD, they address the need to examine more explicitly how to create the preconditions for sustainability.   Iversen and Dindler suggest dividing the notion of sustainability into four different aspects: Maintaining, Scaling, Replicating and Evolving. Maintaining, for Iversen and Dindler, is very much a matter of ownership by the stakeholders. They point out that this is essential for 'stability', which should be the minimum goal for a PD project. However, they rightly point out that 'evolving' is also necessary. This argument converges with the contention coming from the infrastructuring and meta-design perspectives that we have already looked at, that without the possibility to evolve and continuously customise, an application will quickly become out of date and therefore not fit for purpose. Iversen and Dindler's work also overlaps with Wolf and Pipek's in their conclusion that what is really required for sustainability is for a new set of relationships between different parties to emerge that can support the ongoing nature of a project. They explicitly point towards the idea of 'infrastructuring' as a way of describing these networks. (Iversen & Dindler 2014).

The issues of replicating and scaling that are also included in Iversen and Dindlers criteria are new elements for sustainability in our discussions. The implication in the inclusion of these criteria is that sustainability is helped by dissemination and wider adoption. Iversen and Dindler describe in general and quite limited terms how replication and scaling may benefit sustainabilty by indicating the desirability of systems or ideas crossing contexts or becoming more widely used in an organisation (Iversen & Dindler 2014).   Though not developed by these authors, the

identification of replication and scaling as matters of sustainability are quite astute when applied to the FLOSS context.   In FLOSS, it is a fundamental principle that the more widely a project is adopted and information about it disseminated, the more likely it is that an active community will grow and thus start to provide maintenance, documentation, support and further developments leading to overall 'success' in terms of quality, sustainability and broad applicability. In the case of Hublink, we had the ambition to replicate the project for other organisations but lacked the resources to do it. This potential replication was part of a plan for sustainability that did not, in this case, come to fruition.

Bjorvinsson et al make a contrasting argument to that of Iversen and Dindler. They suggest that rather than planning for a project's 'end', the project itself should be seen as open and unconstrained. Therefore, the building in of the kinds of ongoing activities by users that we have looked at under the banners of 'appropriation' used by Wulf and Pipek, 'design after design' used by Pelle Ehn et al, or evolution, used by Iversen and Dindler, are essential precisely because they transcend the need for a finite end point to a project and create a more open ended collaboration (Bjögvinsson et al. 2012).

While Iversen and Dindler refer to the mutual learning outcomes of PD as having an implicit relationship to sustainability, others are more explicit about the need for learning and the design process in general to have an active role in building sustainability. Suzanne Bødker notes,

> "What one does in a project is not only for the project, but should place the organization in a position where the experiences can be used, by the organization on its own, further on in time, and in particular with respect to the future development of the technology (tailorability, etc.)"

> (Bødker 1996 p.220)

Gärtner andWagner (1996) also contend that for participatory design projects to be successful designers need to:

> "Not only to analyze existing actor networks but ultimately to redesign them in ways that help establish and maintain participatory structures".

> (Gartner & Wagner 1996 p.212)

Some writers, mostly coming from a very practical point of view, recognise the fragility of projects and the networks that sustain them. Referring to the community context, Merkel et al (2005) point out that while groups may find they are able to take advantage of their social networks to build and make use of technologies very effectively, these networks are transient and the support is easily lost.

The Hublink project shows that, as an infrastructure, it is all of the things discussed in this section. It is a beneficiary of the capabilities and capacities built up from the design process including mutual learning and trust. Its sustainability is dependent on a network of human and technical components and needs to incorporate constant change. It is also, however, extremely fragile. We go on to discuss the specific context of community informatics and its fragility in the next section.

3.3   Community Informatics

3.3.1 Introduction

In the previous section we have seen how the idea of infrastructure can be transformed from a fixed, material entity into an active, process-based and social concept via the idea of "infrastructuring". In this section we further explore possible dimensions and requirements of infrastructuring through the field of Community Informatics. This enables us to focus in on the characteristics of this specific field. This focus both contextualises the Hublink project and allows us to be more concrete about what infrastructuring might mean in practice and in context.

Work in Community Informatics (CI) is relevant to the Hublink in two ways. Firstly and most importantly for this thesis, CI and related work is able to draw out the specific characteristics of not-for-profit, grassroots and campaigning organisations. This helps us to understand the context within which Hublink was developed and and shapes the theory and practice of the whole endeavour. Secondly, as mentioned above, CI pays particular attention to the issues of 'bottom up' empowerment and sustainability. We have already investigated these topics from the point of view of infrastructuring and a general approach to technology However, CI is concerned with these issues when the objective is social and political, operating with tight constraints and backed by values determined by the aims of the communities served.

As we shall see, CI is a research discipline that is strongly rooted in practice while taking a strong and explicit political stance. The literature is characterised by overriding commitment to community objectives and deals with the real-life problems of grassroots organisations. For me, writing in CI has a refreshingly honest quality, and is able to deal with issues such as trust and longevity of relationships, tensions between theory and practice, failures and shortcomings. In this respect, I find echoes in the experience of working on Hublink, in which it has been a challenge to surface these often hidden or tacit qualities that fully bring experience to research, and find an appropriate style and format for the task.

I suggest that the characteristics of CI can be grouped under three main headings – constraints, values and local connection, and each of these three themes can be used to connect CI with the wider discussion of PD and infrastructuring, and the specific discussion of Hublink.

3.3.2 Defining Community Informatics

Community Informatics is a field of study that looks at the deployment of technologies for community-based groups and social benefit from a grassroots and not-for-profit perspective. For example: Carroll and Rossen emphasise the organisational context in their definition:

> "Community Informatics is the design and management of information systems and infrastructures for civic and municipal-level entities: Nonprofit community groups, non-governmental social service providers, and the lowest, most local level of government (villages, towns, townships)".
>
> (Carroll & Rosson 2007 p.244)

However, while this definition sets a scope for CI, it does not fully describe its perspective. As we shall see, defining a point of view together with a field of operation is crucial for defining CI.

At the 2015 Communities and Technologies conference, two keynote lectures were given; by Michael Gurstein and Anita Gurumurthy. Both emphasised community ownership as crucial for CI. It is necessary to go beyond simply a community context of use; both note that the notion of community is a key driver of neo-liberal capitalism and the profits of large, elite corporations (Gurstein et al. 2015; Gurumurthy 2015). Gurumurthy pointed out that it is the ownership of 'platforms' , such as Google, that allow these companies to dominate both the design and use of technologies. Gurstein pointed out that economic and social divides can become more visible with decreasing the infrastructural divide, and that initiatives such as Facebook Free Basics programme should be resisted saying that such a platform is "in its very design, structured to limit the possibilities for collective action and collective enablement" (Gurstein et al. 2015 p.4)

These comments indicate how CI moves beyond simply operating in the 'community' domain. CI represents, in addition, a clear perspective that seeks to ensure that the full potential of information technologies, including designing and controlling them, is available equally to all in society especially those who are already marginalised or disadvantaged. CI is therefore an explicitly political project that stands in opposition to overriding corporate ownership and power, seeking to ensure that there are alternative routes for communities to develop, manage and deploy technologies according to their own interests. CI is also "activist" in the sense that it gets involved directly with change (Gurstein 1997).   This activism may be manifested on many levels, from engagement with issues of governance or regulation on national or international scale, or at purely local level with, for instance the establishment of a local telecentre or community wireless network.

Concern with the geographically 'local' is a key characteristic of CI, with efforts on the bigger stage such as international lobbying directed ultimately at providing the preconditions for empowerment at a local level.   While, as we have seen, practitioners take a critical approach to the word 'community', acknowledging that it is a term that is currently used in many different ways, local level objectives are seen as the most significant:

> "Developing strategies and applications for using ICT to support local economic development, social justice and political empowerment; ensuring local access to education and health services; enabling local control of information production and distribution; and, ensuring the survival and continuing vitality of indigenous cultures are among the most significant possible applications and goals".
>
> (Gurstein 1997 p.46-47)

CI therefore is defined by a political sensibility and anchored in the actual needs of the people and communities it stands up for. Its work is characterised by continual and iterative engagement with practice and real-world problems. This can be seen, for example, in the ongoing work of Carroll and Rosson (Merkel et al. 2005; Carroll & Rosson 2007; John M Carroll, Patrick C Shih 2015) which shows long-lasting commitment to working with communities, and great awareness and empathy with the small but significant struggles of grassroots groups.   Indeed the emphasis on collective work, tackling shared problems or needs, and the resulting learning and capacity has been identified as a foundational principle of CI by some (Bishop & Bruce 2006). Therefore, practitioners aligned with CI focus their efforts in a hands-on fashion, using their expertise to help build infrastructures in collaboration with grass-roots organisations and bringing that experience into wider distribution and debate through academic and other research.

A minority of work in CI deals with projects similar to Hublink - information systems for closed use within organisations. However, CI is extremely relevant to research on Hublink, as it pays attention to the specific characteristics of not-for-profit organisations and how this affects their development and use of IT systems. This provides much needed insight into the context of Hublink's deployment and how decisions were made throughout the lifetime of the project.

3.3.3 Values Meet Constraints

CI recognises that working with technology in the community sector requires a set of shared values (Carroll & Rosson 2007). Therefore, to work within community organisations, it is necessary to understand how those values are reflected in the day to day running of those organisations and how they may determine the attitude of organisations and individuals to technology. It is here that we need to consider constraints together with values. As grassroots endeavours, community organisations by definition face huge constraints on their resources. Because of this, when undertaking practical work with technology development, it is necessary to take an approach that is aware of both the values and constraints of the sector.   It is this necessity that , for me, distinguishes the sector most of all and in turn has affected the progress

of the Hublink project. The rationale for how the Hublink project has progressed is only possible with a clear understanding of how values and constraints combine.

The effect of the combination of values and constraints in the not-for-profit sector are highlighted by Eleanor Burt and John Taylor in their work about technology adoption by Voluntary Sector Organisations (VSOs) in the UK.   VSOs form the 'third sector' in the UK, ie: a group of organisations with social purpose that are neither part of government nor the private sector. The partners in the Hublink project are all VSOs. Although Burt and Taylor's work is from 2002 and deals with the adoption of basic network technologies such as email, it is relevant to the Hublink project in its discussion of the specific resource constraints of the sector in the UK. More importantly, it highlights how the emphasis on local action is foundational for these organisations, and describes the overriding concern of workers in the organisations with the delivery of services to their constituency.

Taylor and Burt's work identifies tensions between the values of VSOs and the potentials of new technologies. They find that it is precisely the "deeply cherished" values and working practices of the organisations that inhibit the uptake of new technologies in ways that might fully transform the nature and reach of what they do. A major source of tension is between local action and the distributed nature of 'the virtual', by which they mean the potential for the geographic distribution of action and decision making. Combined with a relatively low level of resources for IT system and expertise, the sum total is a tendency to resist the strategic deployment of new systems that may change working practice and may be seen as deflecting attention from local concerns and frontline delivery. However, they also point out that 'demands for accountability and quality of service have never been higher', (Burt & Taylor 2001) - an observation that has proved itself to be true over more than a decade and which provides important background to Hublink – and that some organisations do deploy networked systems to great benefit. Burt and Taylor conclude that those organisations that do succeed tend to have in-house IT expertise at a high level and design new systems in ways that do not disrupt the core values of local benefit and connection.

The recognition of the need to respect the core values of grassroots organisations is echoed in the work of Rosson and Carroll.   They discuss this issue in terms of motivation. They point out that the overriding goals of individuals are helping each other, and that outcomes 'are experienced through the needs of the constituents' (Carroll & Rosson 2007).   For Rosson and Carroll these motivations are key factors in success and sustainability.   They come up with a very similar conclusion to Burt and Taylor, concluding that on one hand, people in community organisations are focussed on their work helping people, on the other hand, if IT expertise is present, it needs to be more widely supported if the organisation is to use it to develop.

Merkel et. al. identify the importance of new technologies for organisational development. They say:

"Technology plays an important role in community organizations enabling them to advertise services, meet the data gathering requirements needed to secure grant funding, and create partnerships to address shared problems."

(Merkel et al. 2005 p.159)

This last point reflects precisely the pre-conditions of the Hublink project. Merkel et al go on to suggest that not for profit organisations suffer for having few resources for technologies and going about their deployment in an ad-hoc way. Rosson, Carroll and Merkel et. al. are writing in the US context about organisations that are much more likely to involve volunteers than those organisations studied by Taylor and Burt. However, they identify similar problems in practice and approach that stems directly from the grassroots context. These can be summed up as: the problem of access to resources for IT on the one hand, and on the other, an emphasis on serving constituents that can mean that people have lower tolerances for giving resources and time to what can be seen as purely administrative matters that do not give direct benefit to local constituents.

The problems identified in these studies are extremely resonant in describing the Hublink project as are the strategies suggested for achieving success. Next we shall see how Rossen and Carroll (2007), among others, see PD as a productive way forward that is aligned with the values and constraints of the not-for-profit sector.

3.3.4 CI And PD: Aligning Values, Overcoming Constraints And Taking Control

"The challenge of participatory design in contemporary community informatics is chiefly one of creating a self-directed and sustainable process of continuous learning".

(Carroll & Rosson 2007 p.19)

PD and CI have clear areas of overlap. Both are committed to democratic processes and the general goals of equality and inclusion. Both share an experimental attitude to how technology can be developed and deployed in ways that have the goals of collective benefit. Both also share many of the same practical problems; research projects in both areas face the challenges of building trust at the outset and, later on, building sustainability and 'exiting' a project without undermining its achievements. As real-world projects, research in both areas, because it is collaborative, has to deal with a changing environment and emergent needs. Both have a concern for what Bjögvinsson et al. calls "resource weak" groups (2012) and how their knowledge and skills can be valued and harnessed for social good. However, it is also worth taking a moment to look at the specific, altered or heightened characteristics of PD when in a CI context.

Carroll and Rosson succinctly defined the twin purposes of PD. Firstly its 'pragmatic' purpose to achieve better systems, and secondly its 'moral' purpose to promote and enable the values of social benefit and individual development. (Carroll & Rosson 2007) . Moving on from this, using values and constraints as our own framework, it seems that both these purposes are heightened when PD is in the community context. The pragmatic purpose of PD is all the more important as it must be a route towards overcoming the tight constraints of community organisations. The moral purpose is all the more important as it must complement and align with the highly valued aims and practices of the community organisations which, as we have discussed in the previous section, strongly define them and those who work in them. However, as Carroll and Rosson have argued, the moral purpose is 'altered' as it becomes more strongly geared towards collective, community empowerment rather than individual development or institutional success.

In CI therefore, control, learning and development are inseparable. Bishop and Bruce define CI research as a coming together 'to develop capacity and work on common problems' (Bishop & Bruce 2006).   For them, learning and skill development is an integral part of deploying new technologies in a community context.   Moreover, control over the technologies is essential. Gurstein is concerned that the political component is not lost. For him, a defining characteristic of CI is:

> "The development of productive relationships with communities that engage their talents and interests in a way that does not involve technological determinism or colonialism by stealth.".
>
>   (CIRN 2015).

Taking a more practical, strategic view, Merkel et al say:

> "On a broader level, control also involves a more long-term approach to managing technology use, planning, and learning taking into account the challenges (e.g. lack of financial resources, few staff members, shifting volunteer base) inherent to community computing settings".
>
>   (Merkel et al. 2005 p.161)

Trust is another common area of concern between CI and PD which is again heightened when the the two are combined. Cristhian Parra suggests that when in a CI context, the issue of trust in a PD research project should be extended to embrace "deep trust" (Parra et al. 2015). For Parra et. al., 'deep trust' represents the extension of researchers' engagement with the community in which they are working into a long, deep and collaborative relationship. In my experience with Hublink, all of these convergences between PD and CI were in evidence and all of them were heightened or extended by the community context in the ways that the writers above have described.

CI therefore has been a great resource in both the realisation of the Hublink project and in constructing a theoretical context. CI helps with approaching and understanding the context of

the project, characterised by the need to understand, first and foremost, its values and constraints.   This approach has been complemented by PD which has offered the tools to build the deep trust described by Parra and provided a set of working methods through which control and 'bottom up' power could be channelled and with which mutual learning could take place. My experiences directly echo those of Parra, in which building trust was a slow process and the collaboration between those with IT skills and those from the community partners was not an easy process. However, PD methods offered all of us a productive and often enjoyable way forward.

3.3.5   MIS Versus CI – Identifying some Contradictions

It seems important to acknowledge that community organisations are extremely varied and while attention to values and constraints are always important, they are not the same in every case. For instance, the degree to which a community organisation may be staffed more or less by professionals and how large it is, may significantly change its character and therefore the issues that arise in a collaboration.

In the case of Hublink, the development was taking place in a professionalised although still small and locally based organisation. Although Real, like most UK Voluntary Sector Organisations, maintains its self-help ethos and has a large proportion of staff with disabilities, it is an organisation in which most staff are paid professionals and there is a hierarchical management structure.   Moreover, in the case of Hublink, a primary motivation for the new system was the need to comply with complex quantitative reporting requirements from the commissioner so many of its objectives were inevitably 'top down'. In relation to Community Informatics literature, this leads us into a set of contradictions.

In the monograph What Is Community Informatics, And Why Does It Matter, Michael Gurstein contrasts CI with Management Information Systems (MIS).   For Gurstein, MIS are geared towards efficiency, control and the production of data to enable top-down managerial processes. MIS is under top-down control and does not imply any community benefit.   Gurstein contrasts this approach with CI which should reflect community values such as inclusiveness, transparency and equal access and of course benefit the community (Gurstein 1997).

In the case of Hublink, the operating conditions of the organisation requires it to impose the goals of MIS on its operations, and as a professionalised, hierarchical organisation it is necessary for 'top down' goals to determine its systems. Therefore Hublink has many characteristics of an MIS, according to the definition by Gurstein, in its emphasis on meeting the needs of management and the use of its output for various quantitative managerial tasks. Therefore, this discussion of MIS versus CI brings a significant tension in Hublink sharply into focus and helps to pinpoint some areas of discomfort that are discussed in the project description.   Nevertheless, I would argue that Hublink falls within the realm of CI research in its overall aims of community development and capacity building. CI also helps us to understand the limited resources, values of self-development and dedication to community

benefit that forms the background to this collaboration. Hublink's overall goals and operating context are local, and the principles of local control and responsiveness to changing local conditions are built in, wherever possible, to the project.

Hublink has characteristics of both MIS and CI.   I would suggest that this contradiction need not be resisted.   Instead, it can be seen as an indication that real-world projects, are unique and do not conform directly with the literature. The literature helps us to reflect and in this case, accurately identify areas of tension or contradiction.

3.3.6   CI and FLOSS

Instinctively, CI and FLOSS can be seen as partners, through their dependence on community and freedom from cost. However, if examined in detail, the relationship between CI and FLOSS has several dimensions, some more fully researched than others, and also not without contradiction or hidden aspects.

Free software is freely distributed and can be used without cost.   However, for FLOSS proponents, this is not the important freedom; the fundamental freedom referred to in the free software definition refers to freedom of use – a principle we discuss further in the FLOSS section of this review. On the other hand, it is a frequent misunderstanding that there are no costs associated with deploying free software. In fact, there are very often costs associated with (for example) development, customisation, hosting and maintenance.

So, while free software often implies low cost, the reasons for CI to be aligned with FLOSS lie elsewhere.   These reasons are more fully discussed in the section on FLOSS. However in the context of the CI, there are two aspects to highlight that converge with concerns already raised in this section: community control and shared values.

Looking firstly at control, we see that control is embedded in the fundamental principle of FLOSS; freedom of use.   This is translated into the enshrinement of users' right to access and to alter the source code and use it for any purpose.   While this form of control is only available to those with technical skills I argue that this does not make it irrelevant for community organisations. Even if an organisation does not wish to alter the workings of a programme, related freedoms are also important. For instance, an organisation should always be able to extract its own data for transfer to another system, understand its structure and freely create copies or backups as needed. Organisations should also be able to choose their technical partners, so that developers of their choice can maintain or customise the system under conditions that they specify.   These freedoms are a significant advantage in contrast to proprietary systems that lock customers in to working with specific companies and often restrict ways of storing or re-using data. These restrictions are commonly referred to as 'vendor lock-in'. In addition, even though FLOSS solutions are not zero cost, they can be found to have more predictable costs, and the costs that do arise can be invested in local economies.

As an example, the Greater London Authority is engaged in a programme to convert all of their IT infrastructure to FLOSS, firstly so that costs can be more predictable and usage more flexible, secondly so that in-house expertise is invested in and is therefore able to be more responsive to changing needs and requirements and thirdly so that any outside contracts can be targeted to support the many different software companies that are part of the local economy (Graham Lane, 2015, pers. Comm, 20 Oct).

Moving from discussions of cost to discussions of values: we find well-documented and well-argued rationales to align FLOSS and CI. Michael Gurstein states that there are direct parallels between ICT enabled 'communities of resistance' and the 'communities of production' within which Open Source software is being produced (Gurstein 1997). In his keynote to the Communities and Technologies conference, he aligns CI with peer-to-peer production of all kinds, including open source, in opposition to corporations such as Microsoft or Walmart (Gurstein 2015).

Anita Gurumurthy unites both practical and political perspectives. For her, FLOSS is both a key practical tool with which to create community technologies and a way to promote practices and communities which can be seen within a constellation of allied political movements. She says:

> "The contemporary terrain of such regenerative politics spans many movements – open source software, urban farming, open science, alternative money and more. This struggle over competing values calls upon our collective will to explore institutional structures outside of the structures of capital".
>
>   (Gurumurthy 2015 p.9).

The discussion of FLOSS is taken further in the next section of this review, and in the project description, it is given a thoroughly practical dimension.

3.3.7 Hublink and CI

In this section we have looked at community informatics; how it describes a context for the Hublink porject and how, by using the constructs of 'values' and 'constraints', we can connect CI to the other themes of this thesis, FLOSS and PD. The Hublink project shows how specific community values and constraints have come together to create a productive way forward that involves FLOSS and PD creating working software with the ultimate goal of supporting community objectives.   The Hublink project description also highlights the importance of a learning process to the longevity and continuing relevance of a CI project.

Nevertheless there are still contradictions in the aims of Hublink as it seeks to be both a management tool and an exercise in community development. The practical contradictions we find in Hublink are mirrored in the contrast made in some CI literature between MIS and CI. Therefore we can say that CI theory has helped us articulate the contradiction and refines our understanding of both community organisations and CI.

3.4   Free and Open Source Software

3.4.1   Introduction to FLOSS

In each of the previous sections of this review (PD, Infrastructring and Community Informatics), FLOSS has been mentioned briefly with a short sketch of its relevance to each area. In this final section of the review we look more closely at the detail of FLOSS, why it is different from other software and what is significant to the areas already studied. This exploration of FLOSS is essential background to understanding both the project description and the findings of this research, and fairly high level of detail is required to give background to the evidence provided in the project description.

At its most basic, Free and Open Source Software refers to software tools that have been developed and released under specific conditions that guarantee their transfer to and continued use in the public domain. These conditions are enshrined in a legal mechanism, which is itself guided by an ethical approach. At the core of that approach is a well-defined interpretation of freedom in relation to an artefact; a definition that centres on freedom of use as opposed to freedom from cost. The distinction is famously articulated in the Free Software Definition:

> "Free software" is a matter of liberty, not price. To understand the concept, you should think of "free" as in "free speech," not as in "free beer".
>
> (GNU 2015)

This precise definition of 'free' is also embedded in the use of the acronym FLOSS (Free/Libre and Open Source Software), in which the use of 'Libre' refers to the distinction that exists in the French language between free from cost (gratis), and libre (freedom or liberty). In much of the literature the acronym FOSS is used, but in the context of this research, the 'L' is maintained to underline that it is the freedom of use that is the most important theme that links to PD and CI on the levels of both values and practice.

A number of different licenses, for instance the GNU Public Licence, are applied to FLOSS projects. These licenses govern the distribution and use of free software, guaranteeing the freedom to use, change and distribute FLOSS software and its derivatives for any purpose. The caveat in most versions of Free Software Licenses is that derivatives must also carry the same freedom enshrined in the license. The legal construct of FLOSS licenses is also known as 'copyleft', clearly signalling that this is a strategy of appropriation, the using conventional idea

of copyright but for the ongoing protection of freedom of use. Via copyleft therefore, a snowball effect is created in which change is embraced and the effort of continuous customisation is focussed back into the public domain.

There is a distinction between Free Software and Open Source which can be seen to mirror some of the twin emphases in PD between the ethical standpoint and the need pragmatic results identified by Carroll and Rosson (2007). The Free Software movement, founded in 1983, is very much focussed on the ethical stance, as indicated by the following quote from the Free Software Foundation:

> "To use free software is to make a political and ethical choice asserting the right to learn, and share what we learn with others. Free software has become the foundation of a learning society where we share our knowledge in a way that others can build upon and enjoy".
>
> (Free software foundation 2015)

In contrast, Open Source emphasises the practical outcomes for individual users and businesses. The Open Source Initiative was founded in 1998 concurrently with the much greater commercialisation of the internet and other digital technologies as a strategy to make the principles of unrestricted access to source code more business-friendly. As developer and academic Mako Hill observes, free software offers "freedom for users, not software" (2011) , and, once again echoing a PD approach, connects human-centredness to the material artefacts of software while Open Source is concerned for the product within the market (Hill 2011).

Nevertheless, for this research project, a detailed examination of different Free Software licenses and their nuances are not a core concern.   This project takes a practical perspective and aims to draw upon experience to develop connections.   We take an interest in how the patterns of production and distribution give FLOSS software particular characteristics that impact on its implementation in a particular context. The differences between Free Software and Open Source are not sufficient to impact on this discussion; both enshrine the flexibility of use which are the most important factors in maintaining stability and meeting the ever-changing needs of the Hublink project.

3.4.2 FLOSS in Research and in Use

FLOSS has become a well-studied phenomenon within several different areas of academia. Some studies focus on legal frameworks and the variations of licence types as described above. Many focus on community participation, individual motivation and the mechanics of geographically distributed work – all of which are goals that many corporate entities aim to achieve, but often with lesser levels of success than FLOSS projects (Crowston et al. 2005). Other studies are focussed on the politics, social processes and values of so-called 'peer' production, sometimes asking how these can be applied in domains outside software

development. (for example, Coleman 2013), or looking at how peer production interfaces with the business models and the activities of commercial companies. (for example, Capiluppi et al. 2012)). Still others look at how FLOSS software development practices such as requirements analysis, testing and maintenance compare to more conventional commercial models (for example, Nichols & Twidale 2003, Scacchi 2004, Alspaugh & Scacchi 2013)

While all of these fields have some relevance to this study, the main focus for this research is in the realm of implementation and use.   This is a lesser studied area (Crowston et al. 2010) . Moreover, Crowston et al. (2010) also point out that an especially underexplored area is the cyclic nature of development; how users become developers, and how the outputs of and feedback from projects are used and transformed as new tools for further development. In other words, while much study of FLOSS takes on social and technical aspects and as such is aligned at least implicitly with the socio-technical approach, very little deals with FLOSS outputs deployed in different contexts, and how these deployments feed back in to use. FLOSS software development communities have been studied in terms of their approaches to work organisation and project governance within projects, but there is much less analysis of how these values affect the use of the software in different contexts.

Mirroring these gaps: FLOSS is mentioned reasonably often in PD, CSCW and meta-design literature as being aligned on the level of values (for example, Giaccardi & Fischer 2008, Blomberg & Karasti 2013), or mentioned in general terms as having potential to contribute to PD (for example Ehn 2008, Fischer 2003) (DiSalvo et al. 2012)(Botero et al. 2010) . In addition, several well-documented projects that involve PD use Open Source software. Some are long running and successful such as DHIS that has already been mentioned. Others are briefer, such as the study by Luke et al. that provides a reflective account of a project that didn't work as well as expected and thus provides many useful lessons (Luke et al. 2004). Stevens et al, in their BCS Weasel project, extend an existing FLOSS project to investigate the themes of design for tailorability (Stevens et al. 2009). This provides an interesting case study but is not one that is in ongoing use. So there is still scope to add the practitioners' view and to start to be more specific about how and why specific attributes of FLOSS projects are of benefit to PD and the contexts in which PD is often deployed.

I have identified two themes through which to examine the areas of overlap between PD and FLOSS, link to the infrastructuring theme and give background to the Hublink project description. These are: Informality and emergence, and Extensibility, generativity and co-creation. These themes will structure the rest of this section.

3.4.3 Informality and Emergence

FLOSS software development has been perhaps most famously described by Eric Raymond in his essay from 1998, The Cathedral And The Bazaar. A great many FLOSS projects were up and and running at that point with well-described and reflective processes in place (for example the Debian project documented by Biella Coleman (Coleman 2013), but Raymond made an important intervention by writing a short, accessible article that, for the first time for many

people, explained the motivation and processes within Open Source.   Based around a series of numbered assertions, Raymond's number one statement is: "Every good work of software starts by scratching a developer's personal itch" (Raymond 1998). It's implication is clearly that developers are creating software for themselves; in other words the developer is also the user - this is a major departure in the conventional view of the user and developer relationship.

This view of how FLOSS projects emerge and develop, in which users and developers merge is backed up through research including (Scacchi 2002, Nichols & Twidale 2003, Barcellini et al. 2014, Jullien & Roudaut 2012). For instance, Nicholas and Twidale applied conventional usability tests to some FLOSS projects. Their findings suggest that projects do not perform well against these criteria, but nevertheless, the authors admit that Open Source projects can be successful, even if not problem-free:

> "This success is, at least partly, derived from the similarity of the experiences of the members of the developer community. When the user group is distinct from the developers these differences can easily generate usability problems: assumptions that work within one community don't cross over to the other"

> (Nichols & Twidale 2003)

In conflating users and developers and foregrounding the pragmatic meeting of immediate needs, the conventional industry/academic view of a software development life cycle and structured processes for requirements that gather and identify stakeholders is immediately challenged. This is replaced by a much more informal and emergent process in which tools and practices shape each other. While this is taken as a negative in the work of Nicholas and Twidale, others have taken a positive approach that works backwards from the success of the projects and approaches these processes with curiosity.

Informality is the theme of Walt Scaatchi's deeply descriptive account in 2003 of how open source projects gather requirements. His paper shows that open source processes tend to be deeply at odds with the formal Requirements Engineering (RE) processes, or I might add, any defined UCD or PD methodology   Nevertheless, FLOSS software can be fit for purpose, usable and widely adopted (2002). Scaatchi re-iterates this point, and refines the findings, in a more recent publication with Alspaugh Understanding Requirements For Developing Open Source Software Systems (2013)

In his first investigation, Scacchi shows how, in the Open Source projects he studied, requirements are not formally described. Instead, they can be found implicitly embedded into narratives and social interactions and found peppered online in forums, email archives and bug tracking software. Scaachi found that requirements are in no sense 'elicited' and no data is gathered.   Instead the project emerges from needs and desires, and features are often not even traceable to a single origin.   Most interestingly however, he points out the absence of any kind of formal modelling (for instance using notations or logical languages) that in conventional RE

practice is seen as so necessary to bridge the 'real' world with the logical descriptions required by programmers. Instead he suggests the term 'software informalisms' to encompass the varied forms of descriptions found on a wide variety of forums (Scacchi 2002).

Scacchi suggests that there is no reason why a formal modelling process could not be instituted; it is simply not done because there is no need for it.   He suggests that there is a replacement for this bridge between worlds. This bridge is the shared mental model that emerges among developers from all the varied narratives, descriptions, diagrams and screenshots that circulate in these informal ways. However this mental model is also constituted from the prior knowledge of the developers of their field, or added research that they take on once involved in a project. One of Scacchi's case studies is the development of software to process x-ray astronomy and deep-space imaging data. In this case he describes the importance of the developers' prior knowledge of the astronomy aspects as essential in being able to create software from informal descriptions (Scacchi 2002).

The same research theme is refined by Scaachi and Alspaugh in 2013.   In this study the basic findings of the earlier work is reinforced and expanded.   Through a number of case studies they further investigate the same "conundrum" as the earlier study; that so may FLOSS projects are successful and widely accepted while still not conforming to any industry recognised requirements gathering processes. In this study they refine the idea of "infomalisms" from the 2002 research, replacing it with the term "provisionments".   This new term is used to indicate an emphasis on descriptions or prototypes that demonstrate potential solutions. They point out that in this focus on "solution space", they contrast with most RE methods that begin with a description of the problem. (Alspaugh & Scacchi 2013). Like the previous study, it is noted that these descriptions may appear in any number of online platforms that are used by developers to communicate and organise their work.

Why is this focus on the productivity of informal processes and shared identity between users and developers important for my argument and for understanding the Hublink example?   The answer is threefold; these three points being key to the central argument of my thesis.

Firstly, the continual meeting of the needs expressed by FLOSS participants is a way to understand how and why FLOSS creates a shared resource in a community setting. If developers are working in similar contexts – for instance the not-for-profit sector – they will have at least some shared needs. These will be shaped by the values and constraints of those contexts. It then follows that tools will emerge that are of common applicability. This point is further developed in the next section on modularity and generativity.

Secondly; the findings provide another view on the theme of 'design-in-use' as a necessity to create effective software. Fischer and Giacciardi have argued that FLOSS software can as a whole be seen as a continuous meta-design project (2008).   Scaatchi is more precise and describes the process of continual expansion and improvement as continuous 'reinvention'

(2005) . And, in an echo of our discussion on PD, mutual learning and infrastructuring, links emergence to both learning and community:

> "Reinvention is a continually emerging source of improvement in F/OSS functionality and quality, as well as also a collective approach to organizational learning in F/OSS projects"
>
> (Scacchi 2005 p.10)

Thirdly, and most importantly for this thesis, the PD process itself is a route towards producing the 'shared mental models' that Scaatchi claims is so important for making informal processes able to work (Scacchi 2002). This could be seen as another way of describing the 'mutual learning' that occurs in PD. The importance of prior experience and shared mental models also opens up some new and interesting questions about the role of developer in an environment where PD meets FLOSS and links to the idea of key roles for individuals with domain knowledge and technical skills.

All three of these points are illustrated by the Hublink project and its use of the Open Source package Drupal. On the first point, Drupal has a wide user community, many of which come from the not-for-profit sector, either from small organisations or much larger governmental ones. Via the modular architecture of Drupal that we explain in the next section, this has resulted in a large amount of very useful and often well-maintained resources.[3]

On the second point, the need for some kinds of design in use has been a key feature of this project, and is a highlighted feature of the project description Evidence shows that it was the collective learning that took place during that design process that allowed continuous customisation, and that there was a feedback loop between learning about customisation and contributing ideas for further development.

On the third point, because of the constraints of the context we worked in while creating Hublink, we used many strategies that Scacchi has described as "informalisms". These were useful for this project as not imposing new tools or conventions meant that there were fewer barriers to participation for our community partners. I would argue that these were effective forms of communication in our case because of the shared mental model we had built up through the PD processes. However, there are also problems with informalisms that we will return to later. In addition, while participation in the design phase for knowledge about the project can be empowering, our experience is that it also leads to fragility. This is illustrated in the project description by the changes that occurred when key staff who had been involved in design left the organisation.

In the next section we look at how the informal and distributed nature of FLOSS projects influences their structure and further facilitates ongoing change.

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3 There are some other sectors that also use Drupal widely and are well served by community contributed modules, for instance publishing.

3.4.4 Extensibility, Generativity and Co-creation

> "Generativity is a system's capacity to produce unanticipated change through
> unfiltered contributions from broad and varied audiences".
>
>   (Zittrain 2008 p.70)

FLOSS projects almost always depend upon distributed teams of people working
simultaneously on different aspects of a project. This requires both organisational tools and an
architecture for the software itself that allows independent work to take place. Examples of
enabling tools include sophisticated source code repositories such as Git, work allocation or bug
tracking applications such as Bugzilla, or Trac, and email list managers such as Mailman.
Indeed, such support tools are some of the oldest and most long-running FLOSS (providing
more evidence for the productivity of the user converged with developer model we have
explored in the previous section).

This distributed and independent working favours particular kinds of designs at the level of the
software architecture. Crawston et. al. note that modularity tends to be a feature of OS projects
as it makes them extensible by different levels of end user. (2005)This observation is also made
by several other researchers (for example, Allen 2012, Stevens et al. 2009, Alspaugh & Scacchi
2013). Overall, the important point about extensible architectures or open architectures is that
they are friendly towards multiple and changing uses and multiple contributors.

These architectures are often visualised as either a stack of layers, or as concentric circles. They
are based on a structure where a stable core or foundation layer provides baseline functionality
and extensions to this functionality should only be done in limited, tightly defined and well
documented ways. These interfaces between core and extensions are often called APIs
(application programmer interfaces).   The core or foundation layer can be treated as a kind of
black box which a developer of an extension, module or plugin should never change nor even
need to understand. All a developer needs to know is how to interact with the core, they do not
need to know its inner workings. In this way, so long as the API remains unchanged, the
functionality of the core and the extensions can be continually improved and maintained
completely independently of each other.

This technicality is important as it shows that design choices that enable distributed working
also tend to enable generativity. We have seen that generativity is linked to sustainability:
Firstly, by allowing simultaneous and independent maintenance and improvement of different
parts of the system which benefits all users.   Secondly, generativity widens and deepens usages
and, through the processes of community building already described, adds to the total effort
focussed on a particular project.

Noting that this can happen with hardware as well as software, a good example is the meteoric rise of the Raspberry PI low cost computer which, because of its accessibility and extensibility, has quickly spawned a huge and international community of hardware components, software developers and creative users which in turn creates greater generativity.

This generativity has led to many benefits, but it is still worth noting its disadvantages. Hill & Monroy-Hernandez (2012) concluded, after a study involving the Scratch graphical programming environment for children, that greater generativity tends to mean less creativity. Scaatchi and Alspaugh (2013) also note that in the world of software informalisms, the 'problem space' is not investigated enough. It seems that extensibility and generativity encourage people to think very pragmatically about what is possible with the tools they have, rather than to abstract themselves from possible solutions and take a clear look at a problem from a fresh perspective.

3.4.5 Generativity and Extensibility in Practice - Drupal
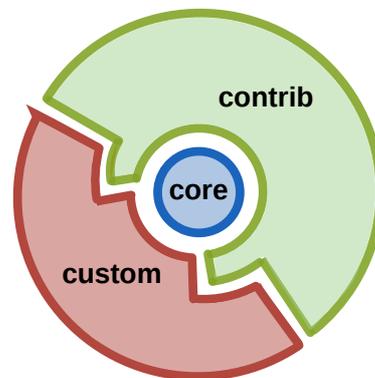
Figure 9: Drupal structure

Drupal, the FLOSS project under the spotlight for this project because it is the framework used to build Hublink, exhibits extensibility and generativity very well with its strict adherence to a 'layered' model and use of APIs as described above in more general terms.

In Drupal, a relatively small 'core' of modules implements the fundamental functionality of a content management system (CMS), for instance managing users and roles, basic content and functions such as installation and logging in. The core is maintained to high standards with rigorous testing and peer code review. The core also provides various APIs, which in Drupal are called 'hooks'. Through these hooks, a developer can add to or modify core functionality without having to alter core code. Figure 9 shows this structure.

The Drupal project has an enormous array of 'contributed' modules, some far more widely used than others, that extend Drupal and enable its customisation via web-based configuration or allow the user interface to be transformed via 'themes'. [4]At the top layer, individual developers may further customise Drupal for a single project or purpose, again using the hooks or APIs of

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4   Themes are collections of code files that alter the appearance but not the functionality of a Drupal system.

the core modules or additional API's provided by contributed modules. All Drupal developers will have knowledge and experience of both core functionality and the most commonly used contributed modules making it easy for them to work on different projects across different organisations. In addition, they will have knowledge of the how the 'hooks' system is used and therefore be able also to understand and maintain custom code reasonably easily.

This easy to understand and structured extensibility has led to the extremely large number of contributed modules for Drupal. This has enabled Drupal to be deployed in many different contexts and on many different scales. Some of the larger and more well-resourced projects will employ developers who can write and maintain modules or core functionality as part of their job. This supports the less well-resourced projects. But all of these usages depend on a robust core. In the most recent version of Drupal, Drupal8, there have been 3,290 contributors to core (Drupal 2016) .

Moreover, via contributed modules, new functionality is tested, refined and evaluated. In some cases, functionality generated via modules becomes so crucial to usage over time that it may progress to 'core' in subsequent versions. This possibility to progress from periphery to core has been identified as a more general feature of FLOSS, providing an emergent route for both software features and developers (Capiluppi et al. 2012).

As a FLOSS project however, the core code is open to all and there is nothing technical that prevents developers from changing the core code for their own project. Discipline and adherence to good practice is necessary on the part of individuals. Drupal developers are always urged to adhere to a fundamental principle, which is 'don't hack core'. This principle is there for good reasons, which are stated as follows:

- Doing so will make it complicated, difficult or near impossible to apply site updates such as Security and bug fixes.
- You will make it difficult for those that come after to maintain the site.
- You could possibly leave your site vulnerable to exploits.

  (Drupal.org 2015a)

This list is significant because, together with the array of relevant modules, it is also a list of the reasons to use Drupal in the not-for-profit or public sector. Therefore, we see a link emerge between the modular architecture of Drupal and its actual characteristics when deployed including a high level of feedback between usage and development leading to not just new functions but improvements in security as well.

In the section of this review on Community Informatics we explored the characteristics needed for technologies in community settings. In Drupal we see all those characteristics; community

support, customisability and technical maintenance that benefit the not-for-profit sector with resource constraints and meet the need for reliable, extensible systems and control.

We also see that Drupal as an infrastructure is dependent on the same kinds of systems of standards and community-wide agreed working practices that characterise the general concept of infrastructuring that has been explored in the earlier section. Support for infrastructuring is both human and technical, depending on an interplay of technical characteristics and social processes and structures.

3.4.6 FLOSS, PD and Infrastructuring

This thesis argues that FLOSS can have an important role in 'infrastructuring' for the not-for-profit sector and now, towards the end of the review, we can see more exactly how the main areas relate.

We have seen that the extensibility and generativity inherent in FLOSS projects, via its license, social communities and often technical modularity, leads to particular benefits for the not-for-profit sector. Top among these benefits are the community-provided security and maintenance updates and a degree of standardisation that enables organisations to find and choose new maintainers for their sites and for those maintainers to work quickly and effectively. These characteristics link back to the idea of infrastructuring as developed by Star. We have also seen that the cumulative effect of adoption in specific sectors make a FLOSS platform increasingly effective within those sectors. Finally, we have seen that constant feedback between use and development is inherent in FLOSS.   This both underlines the argument for the need for 'design in use' in general terms, as well as providing tools that can empower users to get involved with customisation.

Nevertheless there is a challenge around learning and expertise, which can be partly addressed through the mutual learning outcomes of PD. The connection between infrastructuring and mutual learning is evidenced in my research via the qualitative interviews. Meanwhile, empirical evidence, taken from an analysis of changes in the code base (see project description section 6), illustrates the way that FLOSS provides ongoing support via its community.

As well as the connections identified in this study, there may be other connections to be explored between PD and FLOSS. For instance, Botero et. al. have suggested that FLOSS can have a role in 'expanding the design space' in PD projects, thus linking FLOSS with co-creation in addition to mutual learning. Botero et. al. argue that the qualities of generativity and extensibility as discussed may provide tools suitable for quick and possibly even participatory prototyping (Botero 2013). This is not the main subject of this thesis but does illustrate the opportunity to create more and concrete connections between PD and FLOSS. This topic, with others, is expanded in the Further Work section of the thesis.

Despite the benefits and connections identified there are also a great many challenges in practice. Section 5 of this thesis is a fuller description of the Hublink project which goes into detail of how the FLOSS, PD and infrastructuring unfold in practice, with many successes and challenges, over a period of nearly 3 years.

3.2 Summary of the Literature Review

In this literature review three fields of enquiry have been identified and developed. PD, CI and FLOSS. Each of these fields have played a key role in shaping the Hublink project both as a practical and research undertaking. Reflecting this, much of the literature discussed in the review is also referenced throughout the case study description that comprises section 5.

At the beginning of the review the socio-technical approach is discussed. It is shown how this approach surfaces the argument that design methods are a choice that depend on ones political view of users and tools, and acknowledges the need to take the context of use into account when embarking on a design project. The first section of the review goes on to show how the 'first wave HCI' (Bodker 2015) conceptualisation of computer users as interchangeable components in an overall system of humans and machines is replaced in 'human centred' approaches to computing with a sensitivity to context, and the re-positioning of 'users' as individual people with varied and valuable expertise, and therefore unique relationships to the tools they use. For the Hublink project, this human-centered approach to technology design is foundational. As the frontline staff took a leading role, the development team tried to capture their context of work and used prototypes, implemented in the work context to gain feedback and guide design and development. We did not use techniques such as lab-based usability testing that takes a depersonalised, experimental approach, instead giving greater weight to collaboration, learning and building peer relationships.

The literature review goes on to explore how PD extends the socio-technical approach by suggesting that users could co-create their tools, and that the shared activity of co-creation has impacts beyond the production of the tool itself. PD has provided a crucial underpinning for this project by providing a grounding for the approach we took to building Hublink with users, a set of methods we could use in practice and providing inspiring examples of how users could be involved in co-creation. The use of PD methods as tools, inspiration or discussion points is highlighted throughout the case study.

This review shows how PD emphasises both the importance of learning, adopting a model of learning that is experiential. This perspective shaped how we staged the design activities used in the Hublink project as shared experiences. Overall, the understanding of PD explored in this review shaped the approach in the practical work to building a collaborative relationship which sought to bring the knowledge and experiences of users and developers closer together.

PD also shaped this project methodologically. The perspective of 'situated action' (Suchman 1986), which is discussed in the PD section of the review, opens up a space for reflective methodologies that were able to investigate people's unique experiences of the design process and the use of the tool, thus uncovering some of the personal and even emotional facets to this undertaking and revealing pressure-points that should be taken into account in future practices.

Moving on to discuss the phases after the design phase, the topic of infrastructuring emerges strongly through this literature review as a way of understanding how projects transform as they reach beyond the design phase, into long term use, in terms that are consistent with PD. This literature has been crucial for the Hublink project as it has provided a framework for understanding the complexity and interconnectedness of phases after design.   It has helped reflect upon the needs and contingencies of a project going into the long term in a way that embraces the social together with the technical.   The review looks at work such as that by Karasti (2014), Karasti and Syyrjänen (2004), and Wulf and Pipek (2009) that observe how participation can extend after design. Together with the work around Metadesign by Giaccardi and Fischer, and 'design-after-design' (Ehn 2008) it is shown that user needs that emerge after a scheduled design phase can be be embraced and designed for. In this literature, the acknowledgement of continually emerging needs open up a space to think creatively about how design and co-creation can continue after the design phase. This positive approach has been crucial for sustaining the Hublink project in which user needs did indeed continue well after the design phase, and additionally changes in the environment took place which required additions or adjustments to Hublink.   The infrastructuring perspective has also been important for the project by providing a framework for understanding how the mutual learning outcomes of PD provide a crucial resource for these ongoing activities of adoption and ongoing customisation.

The second part of this review discusses CI. This is a discipline that attends to the specific needs and values of community-based organisations as they interface with IT systems. For the Hublink project, perspectives from CI have provided an understanding of the specifics of the community context. The twin topics of values and constraints emerge as core concerns that characterise the Hublink project, together with the need for control. Concern for the geographically local and for community groups to have control over their technologies are in the foreground of CI literature. In the Hublink project, CI converges with PD by showing how the mutual learning outcomes of PD enable control.   CI therefore has been important in understanding the specific constraints and priorities of working with community organisations, while also re-inforcing our commitment to PD and guiding decisions around the longer term support structures put in place.

The final section of this review discusses FLOSS. This section is important because it shows how communities meet common needs for the benefit of users over commercial gain, and how productive activity clusters around those common needs. As well as producing technical solutions, this section shows how communities create crucial resources for sustainability such as ongoing maintenance and choice and control for the participating organisations.   The section also shows how FLOSS is characterised by extensibility and generativity which allow for continuous improvement and enhancement. In addition, the review explores work on FLOSS especially by Scaachi (2002) and Scaachi and Alspugh (2013) that shows how informality and

shared mental models can be a resource for design. Their work shows how these shared mental models can replace more formal processes, comprising a useful lesson for PD practitioners whose participatory processes also produce shared mental models.

The precise descriptions and analyses of FLOSS in this section show exactly why a FLOSS based solution is appropriate for a community based project like Hublink, enabling its long term maintainability and support, and uncovering points of overlap with CI and PD. These overlaps are discussed in relation to the work on Hublink in the case study, and returned to in more general terms in the conclusion.

4 Methodology

4.1 Introduction

This chapter introduces and discusses methodologies and methods for my research. The first section is a consideration of different methodological approaches, focussing on the evolution of the Hublink project and the challenges of practice-based research that also involves participation. In this section I discuss the distinction between production methods and research methods, situating this discussion within Participatory Design. I also survey some relevant research methods – Action Research, Design Research and Case Study research - and describe how they can be blended to address the research question and its specific environment. The second section deals with method, and is an account of the actual evidence gathered and used in this research. The third section is a discussion of the presentation of the project explaining how it is consistent with the methodology, theoretical framework and actual practice of this study.

The practical and theoretical challenges of combining a real-world project, research and participation are considerable. My reflections on these challenges were published in 2015 in the International Journal of Sociotechnology and Knowledge Development (Haskel 2014).

4.2 PD and Research challenges

As investigated in the literature review section, this research is positioned within Participatory Design (PD). PD can be summarised as design activity for and with users, with the aim of producing both useful and usable systems, and a set of less tangible benefits to participants such as personal development and improvement of working conditions. On a theoretical level, PD privileges experience and interaction with the real world as the primary source of knowledge (Hagen 2011), and is grounded in a belief that all people should be able to play a part in shaping the world around them.

This research began with a broad area of concern which focussed down through practice. I began the project motivated to explore how the expertise of 'users' can be better harnessed and valued within the design process and took this theme up through undertaking the practical, participatory development the Hublink project. I also wanted to explore FLOSS as both a resource for PD and a related, but different, participatory practice. Hublink has become essential to the everyday work of a number of organisations and has had a long temporal reach. PD was therefore both a means of simultaneously attempting to understand the original research themes and create something new and useful. There was, therefore, always a dual purpose to this research. Moreover, the 'core perspectives' of PD (Bratteteig et al. 2012) tell us that PD work – co-created and co-realised - is never individually owned. From this is follows that the course of participatory work is not fully under the control of the researcher. Taking a socio-

technical view, the system being created is a complex manifestation of interrelationships between human actors, social systems and technological frameworks.

Therefore we see that the distinguishing features of PD, the tensions in combining production and research, and the multifaceted perspective or the sociotechnical approach will lead to a number of difficult issues for research.

In the Hublink project, as will be described more fully in the project description, we faced many challenges, both predictable and unforeseen. Nevertheless, a "collective achievement" (Suchman 2002a p.99) has been realised, which is the creation of a working system that has been in use for more than 2 years by 9 organisations. Creating and maintaining this working system has been, and remains, a significant challenge and responsibility for all concerned. In the meantime, through this work, the general research themes transformed into the focussed research questions about mutual learning, infrastructuring and FLOSS. In summary, the challenge of this project has been to honour the practical commitments of the real-world project while contributing to academic research.

In the next section, I reflect further on the defining features of my project and how they are addressed and accommodated by different research methods.

4.3 Reflecting on research methods

With PD's strong ethical grounding (Robertson & Wagner 2012), emphasis on co-ownership and yet practical focus, research methods used to draw conclusions from PD need to be consistent with its design methods and approaches. I have identified five characteristics of PD that need to be shared or addressed by research methods if they are to be usable with my research.

- Linked to practice and the real world

In the words of Bruce Archer, practice-based research is executed "through the medium" of practical action (Archer 1995).   The kinds of issues being addressed in my project, in common with any PD project, are complex, have no singular definition and change in their constant interaction with real-world events.   They are complex problems which have no right or wrong solution. The practical output therefore is not proposed as a singular, correct, solution, but a collaborative exploration and experiment with potential solutions. A research methodology therefore, must be able to reflect and value the complexities of practice and the unstable, real-world context; able to document a unique, long-term engagement and respond positively to emergent themes.

- Can account for researcher intervention and change

This research comprises an intervention that produces change, in contrast with research that positions the researcher as objective and the situation uncontaminated by the research. Therefore research methods must be able to take into the account the ethical and ideological position of the researcher and, to counterbalance this, generate research data that is reviewable by other researchers.

- Situated

PD emphases its situated nature. Every situation is unique and action can be taken only once, so there is little scope for comparative studies or experiments in a scientific sense. Research methods must be able to take on board the uniqueness of a project but still be able to generate insights with broader applicability that contribute to knowledge.

- Ethical

All research must conform to ethical guidelines. However, PD as a design method places strong additional emphasis on ethics. Research methods should be conversant with the ethics of PD which include values around inclusion, a concern for power relations and accountability to participants and the local situation. Research methods must be suitable for settings in which with the Researcher does not exert full control.

- Provides knowledge relevant to practice

This is a practice-based piece of research, motivated by issues observed in practice. My motivation is to feed back into practice and so my research method need to produce results that are accessible and interesting to practitioners and have scope and claims applicable to practice.

Given the above, research methodologies to be considered are Design Research, Action Research and the Case Study, which are briefly surveyed here. These methods do not dictate any particular method of data collection and analysis, but they do constitute a set of approaches and guidelines within which different forms of evidence can be presented and claims of validity made. I suggest that each of the surveyed methods are relevant and useful to this research, but I finally propose that they should be combined.

4.3.1 Design Research

Design Research is a set of methods and arguments looking at the ways that the practices and outputs of designers can play a part in knowledge production beyond the singular designed

artefact. There are multiple approaches to Design Research with several notable contributors. These range from design science perspectives that investigate the use of empirical methods within design practice to points of view that emphasise the intuitive knowledge and creativity brought to design (Bayazit 2004).

The activity of Reflection is seen by several writers as a key component of design research. Donald Schon - an academic and professional in Urban Studies - suggests the persona of the 'reflective practitioner' and the activity of 'reflection-in-action' as the distinguishing features of design research and by extension, design education. In Educating the Reflective Practitioner he illustrates, via case studies, the value of group work and dialogue in problem solving. For Schon, design activity is neither the testable, scientifically based problem solving activity of 'technical rationality' . Rather it is a 'constructivist' activity that creates something new from a unique context: 'a practitioner's feel for materials, on-the-spot judgements, and improvisations – the forms of his or her reflection in action – are essential to professional competence' (Schön 1983).

Coming from a PD perspective, Simonsen et. al (2010) see Design Research as a bridge between the two separate cultures of Art and Science and even, by extension, part of a move to recognise hitherto hidden or ignored features of scientific research that rely on intuition, tacit knowledge on the part of researchers, and less goal-orientated practical explorations of a problem spaces . These authors link this constructivist definition of design to PD, defining PD as one of several approaches to design that "constructively appreciate the systemic interdependencies between designed objects, use and context, and between designers and the people they are designing for (Simonsen et al. 2010 p.6).   In this formulation, case studies and reflective accounts are the medium through which Design Research is investigated.

Steven Scrivener has gone further in embedding reflection within design research concretely as a method – encouraging transparent reflection within creative as well as primarily problem-solving projects. He defines stages within a design project where reflection should take place and makes a distinction between 'reflection-in-action' (that takes place during defined design stages) and 'reflection-on-action' (that takes place after design stages or in space in between). For creative projects, Scrivener encourages the systematic documentation of these reflections to distinguish design research from straightforward production. In problem-solving projects, the practitioners approach to problems should be shown to be 'self conscious' and 'systematic' (Scrivener 2000)

Bruce Archer takes a rigorous and more wide ranging view of research in design. For Archer, design activity on its own, even if accompanied by the circulation of the design outputs or accompanied by background research, is not enough to comprise Design Research. In order to be research, practitioner processes and outputs much be directed towards a question and should be based on transparent sources of data and evidence. Archer proposes three different configurations for practice and research: studies about practice, studies for the purposes of contributing to practitioner activities, and studies through the medium of practice (Archer 1995).

4.3.2 Action Research

In Action Research (AR), as in design research, processes of reflections are key. AR is a method of research based on repeated cycles of analysis, action and reflection. AR has been developed specifically to deal with situations in which the research itself generates change and, most importantly, offers a research methodology that takes into account multiple participants with different interests and contexts taking an active role. AR acknowledges the active role of the researcher; rather than striving towards objective observations and uses reflection as a shared mechanism to analyse past actions and plan future interventions. AR is collaborative and situated, in that interventions are unique to the context and people involved with them. Accountability to participants and their local concerns are key; research should be transparent and visible, and presented in ways that is accessible and appealing to participants and their communities. In some variants of AR, for instance Participatory Action Research, it is strongly held that participants should share the setting of direction and focus of research together with interventions. Most importantly, AR has been developed specifically to deal with situations in which the research itself generates change and, most importantly, offers a research methodology that takes into account multiple participants with different interests taking active roles (Coghlan & Brannick 2014; Robson 2011).

Being designed for situations of intervention and change, AR is also able to cope with a situation where the research question may, at first, be "fuzzy" (Coghlan & Brannick 2014). Checkland and Holwell point out that AR does not need a strictly defined hypothesis at the outset, as required by the scientific method. Instead, 'research themes' may be identified, which allows research to become more tightly defined in response to practice and reflection (Checkland & Holwell 1998).

Some researchers position AR as a highly self-conscious method in which reflection is used to provide insight into how researchers' experiences and assumptions shape their actions. Brannick and Coghlan suggest that a key method of Action Research is journalling and this should provide a way to record and develop reflective skills. The journal provides a record of events and a series of self-evaluations. Those self-evaluations should be used by researchers to reveal how their interpretations of events or 'inferences' might have led to decisions (Coghlan & Brannick 2014). Other approaches suggest gathering a broader spectrum of evidence, for instance using interviews and ethnographies (Berg & Lune 2004), as would be done in any qualitative research project. These methods can be used to stimulate further reflection as well as document decisions and actions.

4.3.3 Case Study Research

Case study research allows for work that is a deep description and exploration of a real-world situation or situations. The case study can combine multiple sources of evidence and data to

reach an understanding of a single situation. To go beyond simple description and constitute research, a case study should find a way to increase understanding of a bigger problem. While a case study may not, on its own, be able to prove or falsify a hypothesis, a case study should contribute to some larger grouping of studies that together shed light on a topic of shared concern (Berg & Lune 2004).

Yin (2013) suggests that three conditions should be taken into account when choosing a research method. Firstly: the "type of research question", and secondly the "extent of control an investigator has over actual behavioural events" and lastly whether the object of research is in the present of the past. He suggests that the Case Study is suitable for questions asking "how" or "why" – so this clearly fits with my question. As in my research, the Case Study generally focusses on events in the present. Most importantly however, Yin suggests that a Case Study does not require the researcher to have full control over every aspect of the research situation or activity, and the research should be adaptable yet still rigorous. This lack of researcher control and the need for adaptability is a key characteristic of PD.

In case study research, through combining different forms of data collection and evidence, different voices are heard – one of these can be the researcher themselves (Yin 2013). It is therefore suited to projects where the researcher is an agent of change. Because of these multiple forms of evidence, triangulation – or checking – of the inferences of that data are integral to the method and can be achieved in a number of different ways: via the data, by using different methods, by involving other researchers or by employing different theories (Simons 2009).

A practical information systems project such as mine generates a large array of artefacts, observations and documents. These range from documentation of design meetings to working artefacts such as emails and task tickets, through to technical artefacts such as usage logs. In addition, the project also seeks reflections from participants and the researcher. A case study is able to include all of these as potential sources and should be able to use them to contribute to its validity (Simons 2009)

4.4 Evaluating and combining methods

I have suggested that each of the discussed methods, DR, AR and case study research, in different ways, have some characteristics that fit my project and design approach. I therefore suggest that to be capable of addressing my research question and capturing the important characteristics of my production activity, the methods need to be combined.

AR clearly provides a method for research that is complementary to PD. Like PD it is able to cope with emergent questions and its cycles of reflection in collaboration with participants set an ongoing agenda for research as well as practice. AR with PD potentially brings a unifying to an action/intervention and research, the AR element providing an overarching framework for

drawing knowledge out of a (collaborative) action and providing principles for validity. Most valuably: PD and AR are valuable together in being adaptable to change. They need to be able to accommodate emergent questions and should follow opportunities.

AR has many resonances with PD and it is tempting to see AR as a natural partner for a PD project. AR and PD value participation and inclusivity, and acknowledge both the unique situation of research and the active role of the researcher. However, they have different aims in terms of their outputs. As Gillian R. Hayes points out, while the cyclic process of AR may look like an iterative design process, AR enables knowledge production and is much broader than PD which aims to produce an artefact (Hayes 2011). Foth and Axup highlight the different approach to goals in PD and AR. They see PD as having set goals while AR is more open-ended and exploratory (Foth & Axup 2006). Other writers draw on experience to problematise participation in research activities when they are twinned with production. Cal Swann acknowledges that the 'systematic reflection' aspects of AR are more difficult to achieve in a design project than participation in the creation of the designed artefact (Swann 2002). Hearn et. al also suggest that the principles of AR - that includes "all participants have a right to exert mutual influence over the research process" - represents an "ideal situation", with the reality existing along a "continuum of participation". They also point out that there are many barriers to equally high levels of participation in all aspects of a project (Hearn et al. 2009). In her case study on ACTION for Health, Ellen Balka describes discomfort when participants may feel they are "walking a thin line between end-user participation in design and consultancy in academic or research orientated projects" (Balka 2012 p.276). These writers point to difficulties in defining participation for research while strongly advocating for participation in design practice.

It is certainly my experience that participation in PD project is extremely demanding for all concerned, stretching people's time commitments and sometimes straining relationships when problems arise. Echoing Swann, asking people to additionally take part in reflective activities is difficult to ask among many other demands, and simply difficult for participants to fit in to their schedule. Furthermore, while participants will be genuinely invested in the practical outcome and its impact on their organisation, they may not be interested in making a contribution to the academic research in design and software development methods.

Nevertheless, giving careful consideration to the methods and values of AR have been essential in shaping this project and positioning the research. On conceptual level, AR has enabled this research to accommodate emergent themes and provided a model of research in which a broad theme may be present at the outset of research but within which the most salient topic might not at first be clear. In the Hublink case specifically, it could not have been predicted that the project would have been so long running, or that the design in use and adoption activities would have provided such fertile ground for research. Action Research, therefore, has provided a framework in which, through cycles of reflection on practice either individually or in groups, the research themes could be developed along lines that are responsive to the development of the project. In addition, the strong and inclusive principles of participant verification, and the consideration of the accessibility of academic outputs to participants, that are so important in AR have guided my interactions with participants around this research and had a positive effect on my relationships with participants.

Therefore, despite the difficulties I describe in combining AR and PD, I have reached an understanding of AR as having the capability to extend PD by drawing the participants into an additional iterative, reflective process that can generate knowledge of wider relevance while also providing an opportunity for practice to be enhanced by those shared reflections. The group reflective interviews which are a primary source of data in this study are based on this understanding.

Elements of the reflective methods developed by Douglas Schön(1985, 1990) and later Steven Scrivener (2000) encourage practitioner reflection. DR provides a way to link practice and research, explaining how design activity can itself generate knowledge through transparent reflection. The approach of Design through Research could be complementary for some PD projects, with its emphasis on the development of theory and the consequent development of new methods for practical purposes (Zimmerman et al. 2010). The values of reflection are strongly held by both PD and DR, however, DR on its own privileges the individual whereas PD seeks to value and reflect collaborative work and co-ownership of ideas and results. For my project, I have combined some individual reflection in keeping with DR, with reflections from participants, mostly stimulated by collective interview situations, that are more in keeping with AR.

A case study approach is appropriate to my research for several more reasons. It allows a focus on a single piece of practice in the real world, and does not restrict, though any predefined theory or method, the possible findings from that study. Moreover, in the PD context, the case study, loosely defined, is a common format. Therefore, though equally unique and situated, taken together case studies in PD build a body of knowledge that is applicable to further practice and open questions for further work. The case study also provides a potential format for my research by allowing a deep description of a single case that is complex and multilayerd, and combines multiple sources of data and evidence. The case study approach provides a framework for relevance, despite being unique and situated, by being part of a set of similar studies that together contribute to knowledge. It also provides a route to validity, by being able to combine different sources of evidence.

The research question identifies a link – between social and technical processes during design and those processes after design. From a PD perspective, it is the mutual learning characteristic that has the potential to make that link, and exploring that link must involve the participants. The researcher can observe phenomenon such as the developing interest and ability of participants in ongoing customisation. Those phenomena can be shown to exist via empirical evidence such as actual customisations that have taken place. But only the participants can tell us if and how the mutual learning outcomes of PD link to this ongoing 'design in use'. Design Research, therefore, with its emphasis on practitioner reflection is not enough to answer the question. Action Research provides a better and broader framework for participant inclusion but in practice, the context has not allowed for the capture of ongoing reflection by the participants in formats such as diaries. Nevertheless reflections have been captured through group reflective and evaluative interviews that have taken place through the process, and although participants have not guided research, key participants have reviewed and commented upon the project description. However, other artefacts such as emails and tickets are available whose texts may reveal further insights, but which are forms of evidence that do not fit easily

within Action Research. Therefore a number of qualitative research methods, as are expected in a case study and in Action Research but which are not expected to be seen in Design Research, can be used for this study.

In summary, therefore, the methodology for this research is the Case Study, with practitioner reflection (as suggested by Design Research), and collaborators' reflections (as suggested by Action Research). It is through these reflective methods that the research question and hypothesis have been narrowed, in the spirit of Action Research. However, in addition to the reflective element, my research seeks to collect and analyse other sources of evidence,for instance quantitative data gathered from the code repositories, issue queues and emails, which can be included in the case study.

4.5 Validity and Credibility

Validity of research is concerned with whether readers can 'trust your findings' (Simons 2009). In any qualitative research building validity is a challenge and especially in a case study that lacks conventional experimental characteristics such as control, comparison and repeatability.

In a case study, 'external validity' can be achieved by reading within a context of other case studies. Therefore, in this case, external validity can be achieved by situating my work within the discipline of Participatory Design. Through PD I am able to place my case study among others that share not only similar design methods and theoretical approaches, but also deal with many of the same issues of collaboration, emergent questions and shared control over the research.   In using case study research, I cannot make any universal claims, but taken together with other studies I can contribute to extending PD practice and help define new avenues for research.

Internal validity is achieved firstly via triangulation. Triangulation takes place in my study firstly by the use of a number of different, contrasting voices that were elicited and recorded through collective, reflective interviews.   Secondly, results are triangulated though the use of some elements of quantitative data analysis on technical artefacts most notably the 'commit log' to the code base, and also on the record of issues raised for features, support or bugfixes over the lifetime of the project to October 2013 (see Project description, section 6).

Thirdly, I use "respondent validation" (Simons 2009) to both increase the trustworthiness of my claims. Action Research emphasises the need for 'confirmability' or 'dependability' in research (Hayes 2011). Confirmability includes using participants' own words that reflect their multiple perspectives, including points of view that might be in conflict or disagreement with other participants or the researcher. This use of primary material must be backed up by checking by respondents (Hayes 2011).   Therefore, for this research I have designed a format for the project description that allows extended direct quotations from participants. Key participants have read and checked both the project description section of this thesis, plus drafts of the

introduction and conclusion both so that they may approve the use and attribution of their quotes and also to verify the accuracy of the account. They have also checked the case study paper that was published in the Proceedings of PDC 2014 (Haskel & Graham 2014) , included as Appendix 3.

Respondent validation has been a crucial part of completing this research, both adding weight to the research, and providing continuity with the inclusive ethics of the project as a whole and the theoretical groundings of AR and PD.

Checkland and Holwell add 'recoverability' as a key criteria in validating the results of Action Research (Checkland & Holwell 1998). Recoverability is concerned with making data available and transparent so that although no process addressed by AR may be repeatable, its processes and data may be reviewed - recovered - and re-analysed by other researchers at any time. To address this, the project description is rich with direct quotes from participants. The quotes come from audio recordings of the reflective interviews which, subject to permissions from participants, could be made available to other researchers. The appendices for this study includes raw, contemporanous data from the issue tracker for the project, and I also provide the raw data and and scripts that generated the charts in section 6 of the project description.

 A challenge – rightly raised by the principles of AR - is to make the research work accessible, interesting and readable to my collaborators and to provide it in a format in which they feel empowered to further reflect or contribute. This was another key factor in determining the format of the project description. In their reviews, participants gave positive feedback about the format, saying they found it interesting to read, one saying that the ' quotes really bring the project to life'.

The transparency in the research, its multiple perspectives and the existence of a checking process by participants integrated into the methods, is key in building validity for this research. Finally, the credibility and validity of this research is reflected by the success of the actual practices in addressing the problems the research set out to address in the first instance. In AR terms, this is the application of the 'workability' criteria (Hayes 2011), and should close the loop between practice and research.   In view of the fact that the project was put into production and is still in use, it can be considered that the workability criteria is met.

4.6 Evidence and Data

Yin identifies six main forms of evidence that can be used in a case study. Namely: documentation, archival records, interviews, direct observations, participant-observation and physical artefacts (2009 p.101) . Researchers are encouraged to analyse the strengths and weaknesses of the different forms of evidence, and combine them in ways that can mitigate their weaknesses.   Yin presents a table that evaluates the strengths and weaknesses of each source.

Yin also encourages researchers not be be restricted by this list and to look as broadly as possible to any forms of evidence. He even suggests the value of seeking out conflicting evidence. As a practice based research its clear that the possible sources of data are indeed wide and diverse, and with many different characteristics. This should be taken as an overall strength of the study.

Table 1 lists the possible sources of evidence in my project and their strengths and weaknesses. I adapt Yin's 'source of evidence' categories to be specific for my project. I use some of his terms of analysis of the strengths and weaknesses of the sources (Yin 2013), and add some of my own to be more specific. The two major sources of evidence are additional to Yin's published table but are the most significant data sources for my research. The first of these sources are the 'reflective interviews' that took place in March and April 2014. These interviews were arranged specifically to reflect upon the project processes. It was decided to do these interviews in a group situation to be consistent with the collective working that characterised the project. 3 interviews took place which were audio-recorded, reviewed several times and partially transcribed. In addition a group interview took place in November 2015, at the conclusion of the research element of this project. This was also reviewed and transcribed.

The second main source of evidence is the quantitative data in which digital data which is collected to facilitate production was re-used for research purposes. This style of research is inspired by work in 'digital humanities' (Spiro 2012; Kirschenbaum 2012) in which data pre-existing on digital platforms is re-purposed for research. For this project, the commit logs from git[5] were analysed and visualised to gain insight into the timespans of changes to the code base from the Drupal community on the one hand and to custom code on the other.

Data was also analysed and visualised that looks at the types of issues raised with the developers from the team at Real. The source of this data was a mixture of data automatically generated from the issue tickets system, plus data added by reviewing emails. This was necessary because not all issues were logged on the ticketing system. The raw data is available as supporting material to this thesis, and the process for generating and analysing the data is included with the data in section 6 of the project description.

The theme of mutual learning and tailorability had emerged through practice rather than through research data so 'grounded theory' methods were not appropriate or necessary. The interview data was reviewed for relevant references to mutual learning. Quotes from participants that illustrated the foundational principles of PD were also identified for inclusion in the project description document, especially those that illustrated important contradictions or paradoxes. The main source of validity for this study comes from participant checking. Key participants[6] were sent copies of the project description for review and invited to respond to the following questions:

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5   See section 6 of the Hublink project description for more explanation of Git.
6   Mike Smith, Karen Linnane, Cathie Duncan, Edward Pickering, Ailidh MacCloed, Kate Lomax, Paula Graham.

- Do you think this is an accurate account of our work together?
- Have any important points been missed or mis-represented?
- What do you think of the summary/conclusions?
- Do you have any additional comments?

They were also asked if they could give their permission for quotes to be attributed to them personally. The case study paper about Hublink presented at PDC 2012 (Haskel & Graham 2014) was fully checked by all participants who gave their agreement to the account. They also gave permission for their names and and photographs to be used in the conference presentation.

Source of Evidence	Strengths	Weaknesses
General administrative documentation eg. Emails, agendas, follow up to meetings	- stable - unobtrusive - exact - broad - easily reviewable	- biased by incomplete selection - access can be withheld - reflects unknown biases of author
Participatory Design & training workshop documentation eg. Agendas, meeting notes, audio recordings	- real - contextual - insightful - easily reviewable	- difficult to analyse for research purposes - targeted to production
Written eg. Feature requests/discussions, bug reports	- real - contextual - exact - reflect participation - reviewable, but not easily	- pragmatic rather than insightful - targeted to production - incomplete as complemented by phone calls/meetings - difficult to analyse
Design artefacts eg. Workshop results, paper prototypes with notes, working prototypes	- real - contextual - insightful into technical considerations - record participation - reviewable	- targeted to production - incomplete without accompanying discussions
Diaries and other self-documentation	- insightful - reflective - targeted to research - contemporaneous with events - reviewable, but not easily	- subjective - incomplete
Reflective interviews (participants)	- targeted to research - insightful into context - easily reviewable	- bias due to poor questioning - participant bias
Questionnaires	- targeted to research - easy analysis for research -easily reviewable	- bias due to poor design - narrow in scope
Technically derived evidence eg. version control logs	- exact - reviewable - insightful into technical operations	- not insightful into usage context - possible bias in categorisation - possible bias in data interpretation

Table 1: Sources of data

4.7 Ethics

For the Hublink project, standard Bournemouth University procedures regarding ethics were followed. The ethics questionnaire was completed and the reflective and evaluative interviews, both those in groups and the one to one interviews with partners were preceded by the distribution of participant information sheets and interviewees signed standard BU consent forms. These are available to view on request. Where participants have been named and directly quoted from these interviews in this thesis, this has been approved by them subsequently.   Because the participant have had access to the entire case study document, as discussed in the previous section (4.6) where I highlight the importance of participant checking for validity of this research, they have had access to check their quotes in the context of the case study.

Sensitive personal data about Local Link clients is held in Hublink and the development team recognise this responsibility. Real and the consortium partners are the registered data controllers for the project and specified and have oversight of data protection compliance. No personal data stored in Hublink is exposed in this publication or any other research outputs and no personal data relating to Local Link clients has been stored on the developers' own computers during this research.

However, as this methodology chapter points out, as a participatory project there are ethical matters that go beyond compliance to standard procedures. While this chapter has laid out a position in which the co-owned, collaborative production is treated separately from the research aspects of the project, it has also been important for the collaborative relationship and consistency of values of transparency and control that the participants have awareness of and access to the research aims and outcomes of this project, and some control over how they are represented.

To achieve this consistency I have followed the following protocols. Firstly, in discussions and meetings with anybody connected with the project, whether core participants or Hublink users I have informed them that my development and support work is part of an academic project, outlined the general theme and offered further information on request. *Real* have also informed their partners of the research in several emails during the course of the project. Secondly, I have given access to core participants to the academic outputs of the research where it directly concerns their participation, and sought their comments. The case study paper presented to the Participatory Design Conference (PDC) in 2014 (Haskel and Graham 2014) was circulated to the participants before submission to gain permission to name individuals in quotes and to allow them an opportunity to feed back any comments on the arguments made. Part of circulating this document to participants included an introduction to the PDC itself which provided an opportunity to introduce and position the PD community for the participants. For the presentation of the case study at that events I used both attributed quotes and photographs of core participants as I wanted to emphasise our co-ownership of the project and their contribution. I sought and gained permission from each individual to include their photograph and again explained the context. As mentioned in the previous section, the study part of this thesis was circulated to participants in June 2016 to review and for their comment. The case

study part of the thesis was circulated together with a version of the thesis introduction that set out the academic perspectives that underpin this work.

Though participants have different levels of interest in the academic outputs of this work, through this communication about the academic outputs around the Hublink project I believe I achieved consistency of approach to participation between the values of CI/PD and my methodology.

4.8 Method and presentation: the challenge of 'writing up'

My own voice and perspective is by not means the only point of view or evidence contained in this research. As described in the previous section, this project has included purposeful gathering views of a number of participants at different points in time. These views have been collected via interviews and questionnaires as well as documented in notes and observation through the course of the work. Through this data, different perspectives voices and perspectives add to the project description. In addition there are quite a large number of relevant artefacts – often but not always in digital form – that have been essential in the development of this project and which help present a picture of the processes.

The methodologies discussed and evaluated take clear positions on issues such as multiple voices, relevance and accessibility to participants, and triangulation.   In presenting the project for an academic context, I have struggled with methodological considerations combined with concerns about writing style, structure and presentation.   I have also wanted to achieve consistency between the project write-up and the theoretical and ethical underpinnings of the project as a whole both in terms of approach to participation and in terms of the key themes identified.

In summary therefore, I wanted my project write up to achieve the following:

- The verbatim presence of participant voices

- An accurate reflection of the mood and spirit of the collaboration as well as the facts

- A reflection of the collaborative, creative nature of the project

- An account that participants find accurate

- An accessible and if possible interesting document for participants to read and check

- A reflection of the situated nature of the project, but nevertheless one connected to broader issues and the literature

- A reflection of the multifacted and sometimes contradictory nature of the experience.

To present these sources in ways that are clearly identifiable, I have adapted the format of the 'weave', a format developed by the Journal of Artistic Research that encourages the use of multiple columns in a landscape format so that different kinds of texts and images can be seen in parallel and connected (Journal of Artistic Research 2015). I have used the column format to include complementary elements (the right column) to an overall narrative (the left column). The right column might include visual or textual artefacts from the design or production process, but also includes extended, direct quotes from participants. This gives the freedom to juxtapose voices from different people at different times, as well as incorporate the textual and visual materials that were part and parcel of the collaborative work. The line spacing in this entire document is less than recommended for a thesis to allow for a sufficient amount of text on each of these landscape pages.

Within the extended quotes, visual means are used to distinguish the different kinds of reflection as follows:

     Reflection from the time

     Retrospective view from group reflective interview

The project narrative is chronological, and divided into five phases:

Phase 1: Research

Phase 2: Design and Development

Phase 3: Transition from Design to Use

Phase 4: Design in Use

Phase 5: The long haul: Maintenance and evolution

Figure 10 shows a timeline for the entire project until December 2015, with the phases marked together with key events.
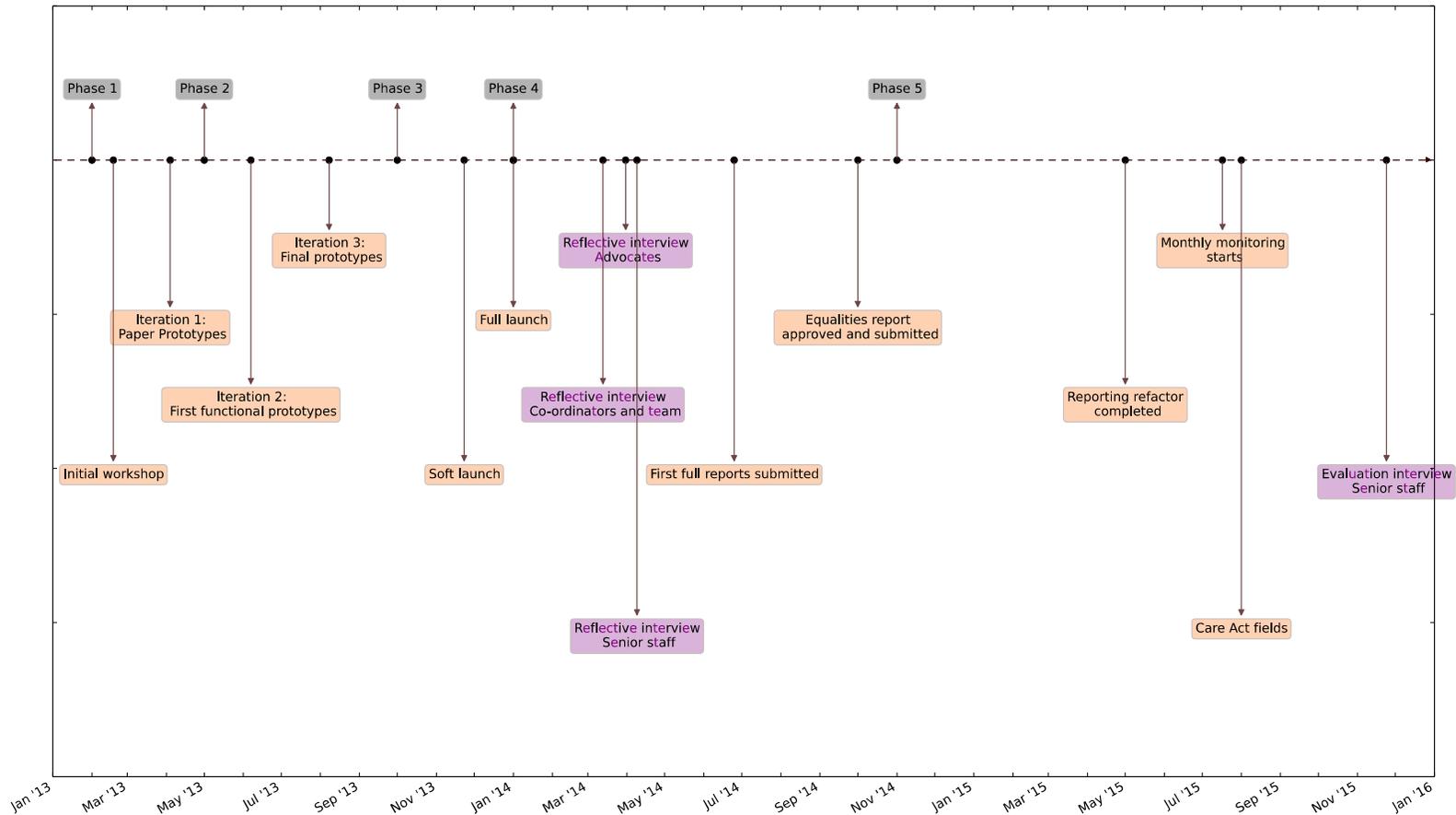
Figure 10: Timeline of the Hublink project. The key events relating to research are shown in purple, events related to production are brown.

Each phase is divided into two main sections: an overall narrative followed by some more interpretative and reflective writing that links to the literature review and theoretical framework. To do this, I have used the main themes from the literature review, namely:

Participatory design: Having a say, mutual learning, co-creation,

Community informatics: control, constraints, values

Infrastructuring: infrastructuring, tailorability, appropriation, generativity/extensibility

The research question of this thesis addresses how using PD during the design phase of a project may benefit stages after design. Therefore phase 1 and phase 2 are primarily descriptive, giving information on how we worked. In phases 3 to 5 the research question is more foregrounded as we are able to show how the experiences in phases 1 and 2 affect the activities of phases 3 to 5. With the exception of the transition phase, which we called the time the 'soft launch' these phases were identified retrospectively.

Following the chronological description of the project, section 6 of the project description takes a contrasting approach. Here, data analysis of the code base and issue queue is presented. This section, by applying a contrasting method to the research, provides some triangulation for the findings of the study.

Finally, to aid reading the project description, table 2 introduces the organisations who are frequently referred to in the text, and individuals who are quoted or referred to.

London Borough of Tower Hamlets	The local government body for the Tower Hamlets area of London, UK. The commissioner of the IAA service.
IAA consortium	A grouping of 9 organisations providing Information, Advocacy and Advice services to the community for London Borough of Tower Hamlets (see above). Information and advice services typically provide individuals with one to one help with issues such as housing, health or legal problems. Advocacy has a different focus and is work that supports people with health or disability issues to speak up for their needs in, for instance, health, education, social care or family matters.
Local Link	The name (chosen by service users) for the work of the IAA consortium.
Fossbox	Community interest company that supports IT in community organisations.
Real	Real DPO Ltd. An organisation that provides frontline services for people with disabilities in the London Borough of Tower Hamlets together with volunteering and campaigning.
Paula Graham	Director of Fossbox
Mike Smith	Chief Executive Officer of Real DPO Ltd
Karen Linnane	Delivery and Development Manager at Real DPO Ltd. Participated in the whole of Hublink development and production
Frontline workers	People who work at Real doing working directly with clients.
Kate Lomax	Front-end developer working through Fossbox
Cathie Duncan	Project Co-ordinator of the IAA consortium Local Link project from Summer 2013 (2nd prototype stage of Hublink) until March 2015.
Edward Pickering	Operations Manager at Real from Summer 2013 (2nd prototype stage of Hublink) until November 2014. A very experienced charity manager with an IT background.
Real Advocate	Frontline worker employed by Real to do advocacy work.
Ailidh MacCleod	Cathie Duncan's successor as Project Co-ordinator of the IAA consortium/Local Link service, joined in April 2015.

Table 2: Key organisations and participants in the Hublink project

5 Hublink Project Description

5.1 Phase 1: Research

5.1.1 Timeline
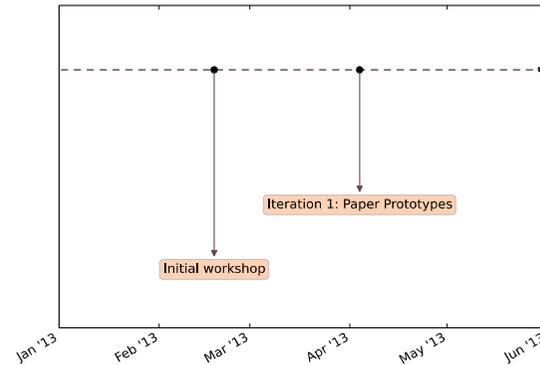
Figure 11: Timeline, phase 1

5.1.2 Overview

In this first part of the case study, I describe the inception of the project and the first stages of research. This phase starts with the initial discussions and ends at the point that a technical build begins. No technology was created and there are only two pieces of work in this phase; an initial workshop and the subsequent presentation and discussion of a set of paper prototypes.

Nonetheless these activities were crucial to the project; laying the foundations for our understanding of each others work and the trust and confidence needed to work together.

5.1.3 Origins

The project that has become Hublink has its origins in changes in the operating environment of VSOs. These changes were directly linked to a set of political shifts that presented major challenges to these organisations and the communities they serve. These changes started in 2010 with the election of the Liberal/Conservative Coalition Government in the UK who brought in a programme of cuts to social programmes and welfare benefits. These changes were backed by a view at Government level that social and community programmes for people needing support should operate following a free market commissioning model, instead of the then existing socially orientated, locally controlled grant funding model. This effectively opened frontline services – many of which were provided by locally based organisations - up to competition from larger organisations, either large national charities or private sector companies. Competing in this environment presents major challenges to smaller, locally based organisations as they are simply not big enough to bid for he contracts on offer. In addition, these small organisations often lack the information systems and management capacity of the larger organisations. One option for smaller VSOs to survive in this environment is to form consortia to tender for contracts for work that could then be shared between the partners.

Figure 12: Fossbox value statement (extract) (Fossbox 2015)

Fossbox is a small Community Interest Company which had worked for several years with VSOs using Open Source technologies to support social action and build sustainable, collaborative technology practices in the Voluntary Sector (Figure 12) . As an organisation well known and respected in Tower Hamlets, Fossbox was included in a bid by Tower Hamlets

107

CVS – an umbrella group for local VSOs - to the Government's Transforming Local Infrastructure (TLI) fund. This fund was intended to support VSOs in this transition to the more market-based funding regime (Cabinet office 2012) .   The London Borough of Tower Hamlets was among several local government organisations who set up structures to try and use the commissioning process to support its local VSO and so the funding was also designed to take advantage of London Borough of Tower Hamlets' explicit efforts to support local VSOs through the new commissioning model.   Consortium working among VSOs had been successful elsewhere, but had required a scaling up of the organisational capacities of VSOs (Chief Executives of Voluntary 2012).

Fossbox therefore had some funds to use to help improve the information infrastructures of small VSOs in the London Borough of Tower Hamlets. After some more general work with the Voluntary Sector in the area, including attending meetings and workshops run by the CVS, contact was made with Real DPO Ltd (*Real*). At this point *Real* were already embarking on consortium working. *Real* had built up partnerships with other local VSOs who also provide information, advice and advocacy services with the intention of creating a combined service which could bid for a tender. The aim was to provide the larger scale of activity that was required by the commissioners, but still maintain diverse, community based services. After a series of meetings, 9 organisations (Figure 13) had agreed to form a consortium to provide information, advice and advocacy to the borough, with *Real* elected through a democratic process to be the 'lead partner'; a role which gave them extra responsibility for delivering and managing the whole service. The service was to be delivered through information 'hubs' at six of the partners' premises, thereby maintaining diversity for clients geographically as well as through the different areas of expertise and community connections of the partner organisations. (Real 2015).

Figure 13: Tower Hamlets Information, Advice and Advocacy consortium partners

At the outset of the project Fossbox had an open agenda about how its expertise and the TLI funding could or should be used to support consortium working. Options that were considered included; using alternative, FLOSS based social networking tools such as ELGG or Crabgrass [1] or designing a strategy for communication across using existing social media platforms. However, following the initial contact with *Real* - A meeting involving Paula Graham, Karen Linnane and Mike Smith that preceded the initial workshop - it emerged that that *Real* already had a clear view that its existing information systems would not be able to meet challenges that would come with the consortium. They already had many ideas about what a more adequate system might be like but had not yet obtained the resources to implement their vision (Real 2015).

5.1.4 Initial group workshop

The initial workshop to start the project was a group meeting held in the boardroom at *Real*'s offices at Jack Dash house in Tower Hamlets near Canary Wharf (Figure 14). The participants were Mike Smith, CEO of *Real*, two front-line workers and two office based staff who both had experiences of IT systems, one from a marketing and knowledge management perspective and one from a more technical perspective. The objective of the meeting was to gather information and set the scope for our work together.

Mike Smith, CEO of *Real*, introduced the meeting though it was subsequently led and facilitated by Paula Graham and myself. In his introduction he emphasised the following points:

Figure 14: Jack Dash Mural at Jack Dash house, pictured during Real Voices event in 2015 (Real DPO Ltd 2015)

Our first meeting took place in rather grand room, below a large mural depicting Jack Dash, a trade union activist from the area. He was shown as a young man addressing a crowd of workers; also as a fiery middle aged and then quieter older man. Given the pedigree and aspirations of Participatory Design, for me it was an enthralling, if weighty, backdrop.

Textbox 1: Self-reflection on the first meeting

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1. ELGG and Crabgrass are FLOSS packages that provide social networking functionality but without the corporate platform ownership.

- The "driving force" behind the project must be a client data sharing tool for the 9 consortium organisations that can also provide the monitoring required by the commissioner and an overview of all organisations activities for *Real* as the lead organisation.

- Information gathering and keeping within *Real* is currently too ad-hoc, with each different worker having their own system and three different electronic databases in use.

- *Real* should take advantage of the opportunity to have "experts" working closely with the organisation, available without financial costs through the TLI funding (Fossbox) and the relationship with the Doctoral student (myself).

The meeting was subsequently facilitated by Paula Graham from Fossbox. In this initial part of the project, as in later stages, Paula used her expertise in technology advocacy and knowledge and connection to the Voluntary Sector to inject new ideas and create common ground. The aim of this initial stage was to gather as much information as possible about the needs and the workflow of the organisation and how that was set to change with consortium working. The workshop facilitation was underpinned by the foundational position of PD that the people who actually do the work know best how it is done (Robertson & Wagner 2012).

The workshop aims were set out for participants in the agenda shown in textbox 2. These aims were facilitated through a shared task in which the group were asked to use coloured sticky notes to document, or map, the major tasks required in a typical case. The mapping of tasks was complemented by more detailed notes and in depth discussions. Through these we learned about key parts of the workflow, such as an initial referral, or the allocation of a client to a

- A large, annotated, chart/flow diagram including

- A 'map' of the PROCESSES - what are the main tasks and who does them,

- What INFORMATION is gathered and how is it recorded?

- CONNECTIONS between the stages

- Notes and discussion on the DIFFICULTIES

- Notes and discussion on the changing environment and FUTURE CHALLENGES.

Textbox 2: Agenda for Initial workshop meeting, 13 Feb 2013, setting out aims.

particular case worker. The tasks were initially arranged as a sequence representing a client journey, but later the sticky notes (Figure 20) were regrouped to represent the information that needs to be at hand for day to day work with a client. These activities comprised 'generative tools' (Simonsen et al. 2014; Brandt et al. 2012) which enabled a form of collective qualitative analysis (Simonsen & Friberg 2014) and facilitated an deep discussion about topics that are not usually explored in everyday work (Brandt et al. 2012) . In the spirit of PD that encourages the adaptation of tools and techniques for a particular situation, these facilitation techniques were applied in a streamlined way that that was appropriate for our situation rather than with adherence to specific methods.

Recurring observations were that information systems in the consortium context would need to be more standardised in order to meet the reporting requirements of the new contract and, from a clients point of view, to create consistency across different organisations. It was also clear that the management at *Real* had a strong need to be able to use the tool to gain an overview of activity across the consortium and within each partner organisation.

The meeting far overran our allotted 2 hours. Adjourning for a quick lunch we re-grouped into a smaller meeting room.   Here the discussion continued and ended with a prioritisation stage where the group gave 'points' to the tasks we had mapped. Those with the maximum points would go forward for implementation. This activity was a way of collectively analysing the data (Simonsen & Friberg 2014), and structuring it so it could become usable for the next stage. To close the meeting, the next steps were discussed. As the lead developer/designer, I explained that I would be producing paper prototypes and showed an example paper prototype from a previous workshop to clarify expectations.   There was some
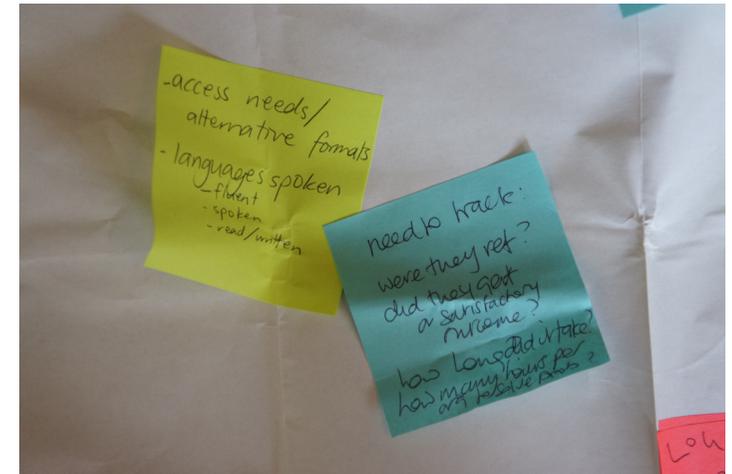
Figure 15: sticky notes from workshop

The overriding feeling from this initial workshop was one of excitement and possibility. People seemed to enjoy the chance to discuss their work and work together on something new. There were varying degrees of excitement about the technology aspect of what it became clear is also a 'work redesign' project. There was no palpable resistance to technology, but there was particular enthusiasm for it from some; two staff members had some computer science background, one more was trained in Librarianship.

Textbox 3: Self-reflection on initial meeting 2

111

discussion about involving the other consortium partners in the next stages as working with them was clearly going to be crucial to the roll-out of our project.

5.1.5 Iteration 1: Paper prototypes

Our first design iteration was based on paper prototyping. The prototypes were developed by me, as lead designer/developer, following a close review of the entire audio recording from the initial workshop supported by the sticky notes. Some additional factual information was requested after the workshop meeting such as categories generally used for impairments and languages. The prototypes were developed with attention to detail and designed to achieve very specific objectives. They were not intended to offer design ideas or choices, but instead to open up a channel of communication. They were a checking and validation tool, but they also acted as a probe intended to provoke new thoughts and ideas. The following principles guided the preparation of the prototypes:

Figure 16: Prototypes meeting

- They should represent as many features as possible that were described and prioritised in the workshop.

- As such, they should provide a means of checking that the features have been understood correctly.

- The features and data fields should be immediately understandable to people with domain knowledge and this should be achieved by using content that represented possible situations. Generic placeholder content (lorum ipsum for instance) was never used. This was so that participants could recognise intuitively what information would be present and how it would be structured.

- The prototypes should resemble screen design just enough to allow people to envisage them as web pages but should not suggest a specific interface design.

IAAplus Consortium Management

Caseworker Notes

Log Out, Emma

Client: Susan Robinson

Access needs: Not telephone, difficulty with stairs
Impairments: Hearing impaired, mobility impaired
Preferred language: English
Full information about Susan

Issue: Housing Advice

Issue Summary: Susan can no longer manage the 3 flights of stairs to her flat and needs to move to a ground floor flat.

Issue opened: 20 June 2011

Contact Notes: This issue

date	duration	location	with	summary
21 Feb 2012	20mins	Telephone	John Brown Housing Officer	Susan is on the transfer list. She can expect to wait approxiamtely... (read more)
11 Dec 2011	1hr 30mins	Client's home	Susan Robinson (client)	Visited Susan at home. She showed me the steep stairs leading to... (read more)
10 Dec 2011	2mins	Text message	Susan Robinson (client)	Confirmed following day's visit
11 Dec 2011	20 mins	Telephone	Sarah Jones (client secondary contact)	Discussed Susan's housing issues and the timescales required... (read more)

Showing most recent 4 contact notes. More notes

Create a new note

Contact Notes: Other issues
Please contact the relevant caseworker for details

date open	date closed	organisation	Caseworker
30 June 2011	31 June 2011	Deaf UK	Julie Green
11 Feb 2011	still open	Tower Hamlets Law Centre	David Blue

Showing all other notes

Figure 18: Paper prototype 1: Project with casenotes

IAAplus Consortium Management

You are logged in as John Jones (Referral worker)

New client

Log Out, John

Contact information

Name: Jim Snow
Address: 27 Tower Hamlets Road E8 6FB
Secondary Contact: Laura Rain   Role: appointee   Show secondary address
Enquiry type: Information [✓]   Advice [✓]   Advocacy [ ]
Impairment: Sensory disability (hearing impairment) [ ]   HIV/Aids [ ]
Brain injury [ ]   Autistic Spectrum [ ]
Young people in transition [ ]   Physical disability [ ]
Older people (not organic mental health) [✓]   Learning disability [ ]
Sensory disability (visual impairment) [ ]

Languages: Bengali / Sylhetti / Somali / Urdu / Punjabi / German / British Sign Language

Source of referral: Self / Carer / Family or Friend / Physical Disability Team / HIV Team / Mental Health Team / Sensory Impairment Team / Children's Team / Hospital Social Work Team / GP / Voluntary Organisations / Other

Access Note: Short term memory problems
Add access note:

Edit contact information

Referral 1

To: Alzheimers Society
Note: Mr Snow requires support for his legal arrangements in respect of his increasing disability in respect of .... (read more)
Date: 13 March 2013

Referral 2

To: Alzheimers Society / Deaf Plus / Age UK / Real / T H Law Centre
Note:

Send referral

Add another referral

Figure 17: Paper prototype 2: Client and referral

IAAplus Consortium Management

You are logged in as John Jones (Referral worker)

Organisation Search

Log Out, John

You searched for: **Dementia**

Active Filters
(-) advice (Type)

Change your keyword
dementia

Filter by type
Information [ ]
Advice [✓]
Advocacy [ ]

Filter by Domain of Service
Housing [ ]
Benefits [ ]
Advocacy [ ]
Advice [ ]
Employment [ ]

Filter by Impairment
Hearing impairment [ ]
Brain injury [ ]
Young people in Transition [ ]
Older people [ ]
HIV/AIDS [ ]
Autistic spectrum [ ]
Physical disability [ ]
Learning disability [ ]

Age UK
Age UK aims to improve later life for everyone through our information and advice, services, campaigns, products, training and research... (read more)
Domains of service: Advice, Advocacy, Benefits, Housing
Type: Information, Advice, Advocacy,
Status: Consortium member

Alzheimers Society
Alzheimer's Society is a membership organisation, which works to improve the quality of life of people affected by dementia in England, Wales and Northern Ireland... (read more)
Domains of service: Advice, Advocacy
Type: Information, Advice, Advocacy,
Status: Consortium member

MIND
Mind is the leading mental health charity in England and Wales who works to create a better life for everyone with experience of mental distress. ..(read more)
Domains of service: Advice, Advocacy,
Type: Information, Advice, Advocacy,
Status: Consortium associate

IndependentAge
A philanthropic organisation providing financial support and friendship for older people (previously known as RUKBA)...(read more)
Domains of service: Advice,
Type: Information, Advice,
Status: Community organisation

Figure 19: Paper prototype 3: Organisation search

- The prototypes should have a 'throwaway' feel to them, with the aim of allowing the collaborators to feel free to make sweeping changes if necessary.

- Where terminology might have been sensitive, for instance in describing equalities and impairments, the correct vocabularies were sought from *Real* in advance and used in the prototypes, and our sample content was double-checked within our group for appropriateness. This was important primarily to build confidence and trust, and secondly to ensure that conversation was not sidetracked into matters of content.

Four prototypes were produced:

- A project including casenotes. (Figure 18)

- A Client and referral (Figure 17)

- An example of a search interface (Figure 19)

- An example of management reports (See appendix 1)

In addition a flow chart was created. See appendix 1 for the full set of prototypes presented and the flow chart. The meeting to evaluate the paper prototypes was attended by Paula Graham (Fossbox) and two senior staff from *Real* (Figure 16).

As a validation tool, the prototypes discussion enabled us to produce a spreadsheet detailing the 'scope' of the application *(A*ppendix 2) – a document hardly referred to in the rest of the process (see Textbox 6). The spreadsheet was more of a management necessity than a design tool, with the visually driven prototypes providing a much more accessible and useful channel with which to design together and build the relationships of trust required to push forward with a complex project.

The prototypes were a first stage in building trust and confidence between Real and the development team, and went a very long way towards that. I believe that they showed our capacity to listen and process information about the organisation into designs. They also showed up areas were there were gaps in our understanding that we could work on more. As both a design tool and a relationship builder, the prototypes were very successful, beyond my expectations.

Textbox 4: Self-reflection paper prototype stage

5.1.6 Reflections on phase 1

5.1.6.1 Having a Say and Mutual Learning

This case study seeks to explore how a PD design process benefits sustainability beyond the design phase. The first phase of work on Hublink described here represents the beginning of that design phase. As such, the documentation of and reflections on this phase are focussed on the application of PD methods and approaches. It is only later that the influence of these after design can be evaluated.

In this stage, PD methods guide the design of our activities and our overall approach. Deep yet efficient collaboration processes were needed to learn about the work at *Real*, and in the meantime, the community partners needed to learn about the development team, our needs and our approach. PD methods provided us with a set of tools, and those we used were chosen because they provided spaces for communication and mutual learning that were uncluttered by technology and less susceptible to problems in participation caused by differences in participants' understanding or experience of using technologies.

In reflecting on this phase, the core perspectives of 'having a say' and 'mutual learning' provide a framework for understanding our activities and their outcomes.

As an outsider, it felt like there was a lot of excitement in the room. People were clearly very committed to the service they provide and making it as good as it can possibly be. The frontline staff were able to define very clearly how they organise the quite hefty administration and record-keeping tasks associated with their jobs; they seemed to very much design their own systems for this that span across electronic means and paper. However people seemed open to the idea of changes and (hopefully) improvements to the systems they work with.

Textbox 5: Self-reflection on initial meeting 1

PD methods, namely affinity diagramming and problem mapping (Simonsen & Friberg 2014), shaped the initial workshop and its facilitation.   Through these methods frontline workers were able to take a leading role contribute rich information about how they work and how they currently systematise their own record-keeping. The activity and discussion revealed details of a workflow which was so embedded in the organisations' work that it is rarely discussed, echoing the core observation in contextual design that service design and information systems design most often go hand-in-hand (Beyer & Holtzblatt 1997). In this project, through making this workflow more explicit it quickly became clear where the current pressure points lay and how they might be amplified in the move to consortium working. For instance, team management activities such as allocating caseworkers to a referral were discussed at length. The frontline workers described a well functioning method for allocating referrals through the use of a special email account that had been created for the sole purpose of functioning as a queue for waiting referrals. While being a really interesting example of technology appropriation as described by for example Dourish and Dix (2007) and providing a prototype of the task, the workshop discussion revealed that this method was not going to be able to scale up to cope with consortium working, which would need to be able to work within and across several organisations.(Textbox 5).

Figure 20: Sticky notes from initial workshop

The participatory methodology for the initial workshop that used a map and sticky notes as its main materials for having a say seemed to work well, but needed to be applied flexibly. For instance, it became evident that for some participants, writing directly on sticky notes was a barrier rather than an enabler of direct participation because of some participants' impairments. This shows that despite the existence of many well established and defined co-design methods to facilitate 'having a say' such methods must always be applied flexibly. An audio recorder was used to document the meeting. This proved essential as only a small amount of the total detail

discussed had been captured via the sticky notes or any other visual means; in our case, it was the discussion that captured all of the detail.

Figure 21: Real Local Voices project logo

Nevertheless the meeting was characterised by a great deal of enthusiasm. Reflecting on the session, observations from Bratteteig and Floyd are apposite. Floyd et. al suggest that systems design can be characterised by social aspects such as the collective excitement that comes with working with shared interests and motivations (1989), and Bratteteig suggests they could even be fun (Bratteteig 2003) .

Discussions on the value of prototyping is present in PD literature from its earliest days, for example (Floyd et al. 1989; Suchman et al. 2002), and the use of paper prototypes in this project was inspired by this.   In our project, paper prototyping proved to be an extremely effective strategy. Their use built trust by providing evidence of the development team's understanding of the discussions at the exploratory workshop while also providing an opportunity to expand the amount of information exchanged.   The staff present from *Real* expressed appreciation for the accuracy of the knowledge about the organisation that they saw reflected in the prototypes, and they provided a concrete basis through which to further interrogate and reflect upon the designs. The contribution of prototyping in our project accords with the description by Robertson and Wagner in their discussion of the ethics of PD, wehre they describe prototyping as providing a way to understand, question and intervene in designs that is open to participation (Robertson & Wagner 2012). Overall, in this project the use of paper prototypes provided a platform through which we could learn about each other, the staff could input and though which the whole group could build confidence to move to the next stage(Textbox 6). Additionally, the prototypes were a tool with which a large amount of

117

information into a digestible format could be condensed, so that creative discussion could take place, as well as being a pragmatic tool for communication. Reflections from participants from the group interviews that took place after the design was concluded confirmed our sense that too much abstract paperwork, for instance spreadsheets of specifications or lists of user stories as might be used if using Agile or Scrum methods, was not going to work well in this context where staff are focused on frontline work and management time and resources are always under pressure (Textbox 6).

The development team were disappointed that no frontline workers attended the prototyping meeting especially as the initial workshop had felt very inclusive. In reflecting on this issue, Robertson and Wagner's observation that the strong ethical values of inclusion are often in contradiction with the pragmatic aims of a project and the need to work within organisational cultures of partner organisations (2012) provides insight. This potential contradiction is perhaps heightened in the CI context where the ethics of PD might at times conflict with the importance of ensuring that the community partners have ownership and control of the project as emphasised by writers in CI such as Gurstein and Gurumuthy (2015).

5.1.6.2 Tailorability

Through discussion and design activities the whole team gained a fuller picture of the increased scale and complexity expected with the shift to consortium working, and it became clear that there would be a need for continuous customisation, or at the very least, the incorporation of new functionality at late stages. Tasks such as establishing and maintaining categories that would be needed for subsequent reporting and data analysis internally were clearly not going to be pinned down until much later in the process. It was emerging through our design activities that tailorability was going to be very important indeed and design could be expected to continue well into the use phase.

This made sense to me, when we did this paper exercise. We sat and we scribbled on it, and we took things away and we added things, and it just made sense. If we'd tried to do any of this online I think I would have been lost… [if it had all been presented on a spreadsheet] I would have cried! *(laughs).* As someone who hasn't used CRMs before, having it on paper like this, where we could easily flip back and forwards, was good, so I wasn't concerning myself with, oh you've got to click that to do that. I was just looking at the information rather than the process of using the tool so that really worked. **Karen Linnane 13 March 2014**

Textbox 6: Reflection on paper prototyping

5.2 Phase 2: Design and Development

5.2.1 Timeline

Deployment to server

Consortium partners meeting

Workflow focussed meeting

Iteration 3: more walkthroughs

Iteration 2: First functional prototypes

May '13 Jun '13 Jul '13 Aug '13 Sep '13 Oct '13 Nov '13 Dec '13
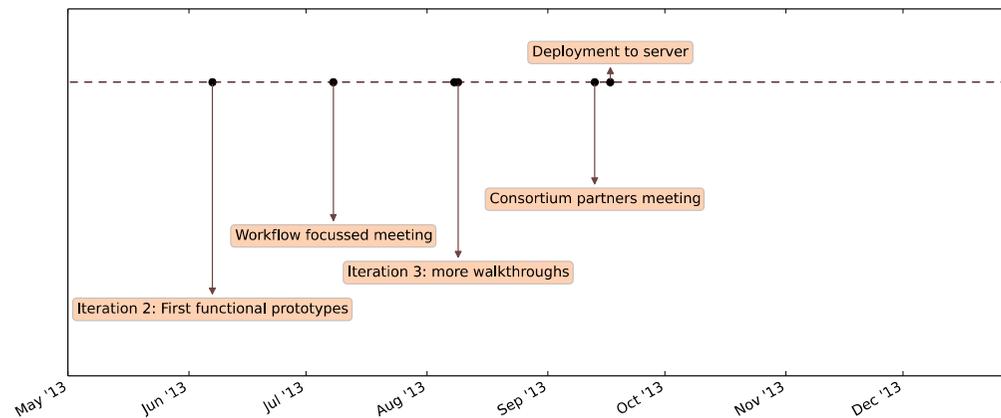
Figure 22: Timeline, phase 2

5.2.2 Overview

This second phase covers the main technical development work on Hublink. In this phase, the main building blocks of the application were put into place and the interface designed and implemented. The phase is based around two design iterations, both centred on incremental, working prototypes. This phase concludes with a more loosely structured development period, which addressed a higher level of detail, mostly related to groups, ownership and visibility of records.

The use of working prototypes with actual users throughout the design phase is a lynchpin of PD and indeed all of HCD (for example (Floyd et al. 1989A, Suchman et al. 2002, Holtzblatt & Jones 1993). In this project, the prototypes fitted the term "exploratory technologies" (Suchman et al. 2002) ; materials through which all participants could explore the problem space and the environment of use, as well as evaluate incremental solutions. In these respects they worked very well and, as is shown later in the case study, gave the added benefit of facilitating a high level of learning and understanding about the application that was important for the future. Our use of prototypes and the activities facilitated around them in this project were also ways that the development team – comprising of myself, Kate Lomax and Paula Graham - could spend time in the users' workplace, ask further questions about everyday work and broader issues that affect the organisation, and gather useful documents.   The importance of spending time in the users' workplace is emphasised by writers including Beyer and Holtzblatt (1997) and in the general approach of ethnographers working in PD such as Bloomberg, Karasti and Suchman. This iterative and collaborative methodology based on prototyping meant that during this phase there was a great deal of contact between the development team and the community partners. Although there was a concentration on technical work in this phase, it was far from being a period in which developers were quiet and desk-bound, this phase was characterised by some quite long, fruitful and often fun meetings.

As the main build phase, it is also at this point that the extensibility of Drupal was most in evidence through our use of many community-developed and supported modules and web-based customisation to achieve our goals. However this section is primarily concerned with the human-centred design process with a discussion of technical characteristics included only when necessary for understanding the design process.
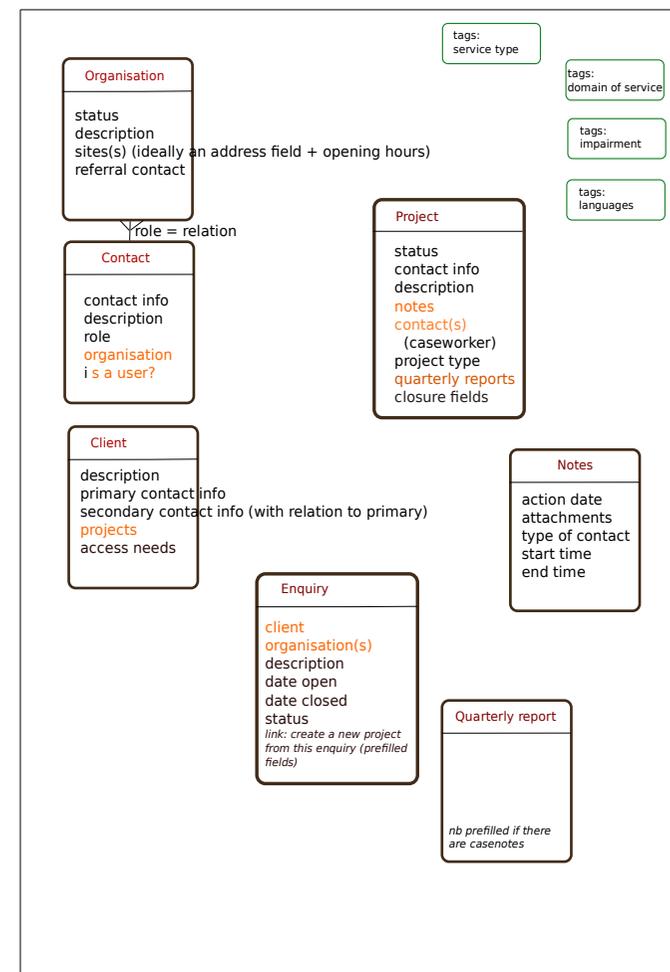

Figure 23: Content types plan as at May 2013, working document

5.2.3   Iteration 2: First working prototype

Iteration 2 was the result of a thorough review of the feedback from the paper prototyping stage and consisted of two working prototypes.   The objective of the first working prototype was to evaluate and expand the basic three content types (clients, enquiry and project) that had been identified during the paper prototyping stage, and to provide a research opportunity for the front-end, user interface design.

For this stage, the main building blocks of the application had to be put in place. These were the 'content types' for clients, enquiries, referrals and projects. In any Drupal project, content types are the fundamental building blocks of an application, comprising of extensible, customisable containers for data. These content types are intended to be extensible with unlimited numbers of 'fields' that are designed specifically to capture the data required in any particular situation (Drupal.org 2015). Therefore Drupal is very well suited to working with prototyping as once a basic framework for content types is in place, fields can be easily added or amended. Figure 23 shows the schematic plan for content types at this stage in development. It should be noted that an additional content type – 'referral' had been proposed at paper prototyping stage, but discussions indicated this would be unnecessary.

This first prototype was presented to staff at the *Real* offices on 19 June. The meeting had a good range of people from both management (2 staff members) and frontline work (2 staff members) . The frontline staff members were not the same individuals as those that had attended the initial workshop. An agenda was circulated to all participants a day in advance (Textbox 7). Myself and Paula Graham from the development team attended and we were joined

Aim of the meeting

> Test the work done so far and make sure we are along the right lines
>
> Create some 'real', representative content
>
> Ensure that the systems workflow suits the way information is gathered and shared in practice
>
> Work out priorities for the next stage especially in usability
>
> Establish a concrete todo list for REAL re: categories etc
>
> Get a feel for the training requirement further down the line
>
> Anything else important

Textbox 7: Agenda for iteration 2 evaluation meeting

for the first time by Kate Lomax, a front-end development specialist who was being supported via the TLI grant to develop the user interface.   The prototype had been installed on a web-server so it could be accessed over the internet, from people's own workstations in exactly in the way that the finished application would be.   The meeting was planned around a simple role-playing exercise in which staff would be asked to act out scenarios that I had defined in advance (Textbox 8), but which I knew from research to represent common tasks. It was planned for these exercises to take place in small groups with one of the development team taking notes in each group.

The rationale for using scenarios and role play was twofold. Firstly the designers and developers wanted to devise ways to find out more about how frontline workers actually do their jobs given that it was not realistic within the resource constraints on both the part of the development team and the community partner organisation to do a full set of ethnographic observations. Secondly we wanted to give people a chance to tell us about their day to day work in ways that enabled them to express what they find significant or notable. So although it might not be a fully accurate way of knowing about client work, it would be a creative channel through which frontline workers could tell us what they wanted us to know. Several PD researchers have referred to the use of improvisational acting to in PD including Brandt et. al. (2012) and Ehn & Kyng (1991).

To open the meeting, the design team briefly explained the main thinking behind the work in the prototypes. However, we did not demonstrate or explain how to do particular tasks. We left this to the hands-on part of the meeting.

- Scenario 1: Capture an enquiry from a person who has not yet has contact with the consortium. From this enquiry, create two referrals to two different organisations who will be copied in to eachother.

- Scenario 2: As a manager, allocate projects to caseworkers

- Scenario 3: As a caseworker, track your existing work by creating a new casenote for one of your clients.

Textbox 8: Scenarios for iteration 2

For the main part of the meeting, the entire meeting split into two for the role play. The two groups comprised a mix of development team members, frontline workers and management. Development team members guided people towards the correct buttons to press and fields to fill out only when necessary as it was a good opportunity to see how intuitive the design and terminology might be to those with domain knowledge so development team members gave an outline explanation and detailed instructions only when requested. In this respect, the methodology draws from the 'discount usability' methods of Nielsen that emphasises the importance of the texts used in interfaces and the basic principle of usability that interfaces should 'speak the users' language' (Neilsen 1997). Members of the development team took careful notes of users' comments and the difficulties encountered. Figure 24 shows the result of scenario 1 in which an enquiry is logged and a referral is made. In the example shown, there is already an existing referral.

In addition to testing data entry for clients, projects and enquiries, the team also showed the first prototype of the 'dashboard'. The development team had envisaged the dashboard as a control centre for workers and managers to help them organise their work. It would show the personalised workload for each person and would have different components for different roles. Figure 25 shows the dashboard for a consortium manager at iteration 2. In this case, the dashboard of organisation managers show incoming referrals to an organisation (My referrals). Then the case load of the logged in workers is shown. The final block is an overview of all referrals in the consortium (All referrals). This design is a direct result of the discussion at the initial workshop about the need for managers to triage new referrals and allocate them to the most relevant case worker. In contrast, the caseworkers dashboard would show only that individual's case load, it would not need to show incoming referrals. The meeting and acting out scenarios was quite a lot of fun, and gave us large amounts of new information to allow us to move to the third prototype.

Figure 24: Data entered from scenario 1

Figure 25: Dashboard at Iteration 2

5.2.4   Iteration 3: Second working prototype

The purpose of this iteration 3 was similar to iteration 2 .   It was still necessary to test the accuracy of the basic building blocks for the data that had established though the development team were reassured that this was broadly correct from the previous iteration. However, many new fields had been added following iteration 2 which increased complexity. This brought the application nearer to fulfilling its purpose and while also revealing the biggest design problems.

Meanwhile, behind the user interface, a custom workflow, which was going to be essential for organising and tracking referrals, had been added which needed scrutiny (Figure 28). However the greatest change was probably the front-end development which been undertaken by Kate Lomax. See Figure 26 which shows a similar piece of data to figure 24, but with the new front-end design. The dashboard had also been further refined.

Though the application has changed incrementally, from the organisational point of view, there was a major change. This iteration was the first in which the new staff (Operations Manager and Project Co-ordinator), who were going to be responsible for delivering the consortium's work, were in post and therefore could participate in the project.

Figure 26: Enquiry in iteration 3

At each of these meetings myself, project manager Paula Graham, front-end developer Kate Lomax and either 4 or 5 members of staff from *Real* attended. The staff members included the new project co-ordinator plus one member of the management team, and either 2 or 3 frontline workers. Because frontline workers are often part-time, attendance was very much subject to their availability so the same people did not attend at each meeting. This had some advantages as we got to work at least once with most members of the team, but also meant that there was a lack of continuity. This lack of continuity was highlighted later as a difficulty.

Iteration 3 was presented to staff over two meetings, one week apart. This time, instead of the very open scenarios from the previous iteration, I, as the designer/developer of the prototype, provided more structured 'scripts' .

125

These scripts (see example in textbox 9) were intended to guide participants through tasks that tested the main functionality of the system. For this iteration, scripts were used to provide more structure and direction. They were intended to help participants get a stronger sense of the direction of the project, but as will be discussed later in this section, they were not used in a prescriptive way as the development team were still were aware of the need and value to provide a platform for participants to communicate and discuss what they thought was important. The meeting once again split into groups, with frontline workers sitting at their own desks, working through the scripts accompanied by at least one development team members taking notes. This approach, making use of observing workers in their own situation, not using sophisticated usability testing technologies such as cameras and eyetrackers, reflects the 'discount usability' approach of Neilsen (1997) . Avoiding lab-based situations is also consistent with the aims and values of PD with its emphasis on collaboration and mutual learning.

These two meetings were long and covered a great deal of detail. In a surprise to us, the discussions combined what might be termed 'service design' with the information technology design. However, the tendency for these two tasks to be entwined, either implicitly or explicitly has been pointed out by a number of writers including Beyer and Holzblatt (1997) .

Working with this prototype showed that while, from the point of view of the technology, the general structure was seemingly fit for purpose and the workflow within and between organisations technically robust, there were still a lot of questions about how the system would meet the challenge of consortium working, or indeed how exactly consortium working would take place. This gap was due to the fact that the consortium itself was as yet unformed. For a

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Example script:

Create a new client, and then a new enquiry for that client

- From the dashboard, find 'add new client'

- Fill in the form, including the 'groups audience' drop down.

- Then find the 'client activity' tab

- Click 'create a new enquiry for this client'

- Click the 'client' tab and check the client has been filled in correctly

- Fill in the rest of the enquiry information and save

- After the node has been saved, you will see the enquiry you have just created listed for this client

- *Click back to the dashboard to find your new content*

Textbox 9: example 'script' for iteration 3

variety of reasons that are discussed later in this case study, input from consortium partners was not present at this stage and assumptions had to be made about how other partners work. Nevertheless, by the end of these two sessions there had been a lot of progress. The basic data entry and been solidly established and the dashboard was not only gaining traction as an idea but sparking off new creative ideas. For example, front line workers who participated contributed idea and idea for how the dashboard could flag up reminders of important dates that would help them to prioritise their workload (Figure 27). Once again, the level of fun, experimentation and creativity reflects the experiences of PD practitioners over a long period, For instance: Floyd et al (1989b) and Bratteteig (2003). It also illustrates the point made by Liam Bannon - that users should never be treated as uninterested in the systems they interact with day to day (Bannon 1991).

Figure 27: Workers' dashboard showing action dates

However, there were still big challenges still to be overcome. I needed to enter a new and deeper level of detail to work out the structure for information sharing and information visibility within and between organisations and teams, and its interaction with the workflow. Although the formal iterations were over, there was still much co-design to be done, especially around these topics of major concern.

5.2.5 After iterations – groups and content visibility

The end of the iterative design cycles were by no means the end of engagement between the development team and *Real*. If anything, engagement and communication accelerated in the period following the final iteration and ending with the deployment of the system into production. This work was particularly focussed on refining workflow, groups and permissions. This work needed to be informed by detail on how a case progresses through the stages of initial

127

referral, allocation to a caseworker, action and closure. This process may occur within a single organisation, but in consortium working a case may also be referred between organisations. Dovetailing with these workflow rules (see Figure 28), mechanisms also needed to be established that would determine the visibility of personal data within and between organisations. It was thought not to be appropriate to rely on individual workers applying workflow state and visibility rules as this would be onerous and error-prone. Instead, our aim was that these should be allocated by the system programmatically according to well specified criteria and rules.

The clarification of these criteria was my next task.   The problem was well expressed in our preliminary discussions around the need for different teams at *Real* for advice and advocacy, even though they are in the same organisation. This need was described to us by staff at *Real* as a need for an 'ethical wall', and was given detail by invoking a scenario. In this scenario, an advocate, whose job it is to support people with disabilities to express their views, may be helping a client challenge the work of a Support worker who also worked for *Real*, but in a different team in the organisation. Through this simple scenario the need for control over the visibility of data between groups in the consortium was made clear.

One of the biggest challenges in the move to consortium working is the extension of the issue illustrated by this scenario to information sharing between organisations.   The system needed to both facilitate the desired degree of joined up working between organisations, while still giving choices to both organisations and individuals about how data is shared.

```
Workflow

#41  #30  #31

Enquiry    not referred -> if no child projects
           referred     -> if child projects
           closed       -> if all child projects are
                              closed
                        or
                     -> if resolution box is filled in
                        then set enquiry date closed

Projects   unallocated -> default
           allocated   -> if caseworker added and no
                              casenotes
           in progress -> if caseworker added and
                              casenote(s) exist
           closed   -> if resolution field filled in
                        then set date closed
                        and
                        check parent enquiry
                     → if all projects of parent
                        enquriry are closed
                        then fill in resolution field
```

Figure 28: workflow summary for iteration 3

This discussion around data sharing went to a new, higher level of detail than the previous iterations. Though unlike the earlier stages, they took place through informal means; emails and telephone calls and some smaller meetings. The discussion was difficult especially as, as has already been noted, the consortium had not yet started meeting or working together. Several different methods to analyse the needs and turn them into rules were tried out by *Real* and the development team. I made several attempts at using visual means to approach this task and in the meantime, quite independently, staff at *Real* were also working creatively as a group to understand and tackle the problem. Figure 29 is a diagram produced by *Real* staff at their own meeting to express and systematise their thinking around visibility of records between groups, in which once again they used scenarios and visual communication, but in this case independently of the development team.

After much discussion and testing, the Drupal suite of modules 'Organic Groups' was found to be able to meet the requirements adequately. As shown later in the project, this set of tools proved extremely valuable to the project later because of their reconfigurability. This reconfigurability meant that later on, the application was able to incorporate changes as a greater depth of understanding of differences between the organisations was reached as they came more engaged with the consortium. The Organic groups module was complemented by a custom module that interacted with the workflow to automatically assign a new project or enquiry to the appropriate group. This technique uses the full potential of the extensibility and generativity in the architecture of many FLOSS projects (Alspaugh & Scacchi 2013; Capiluppi et al. 2012).
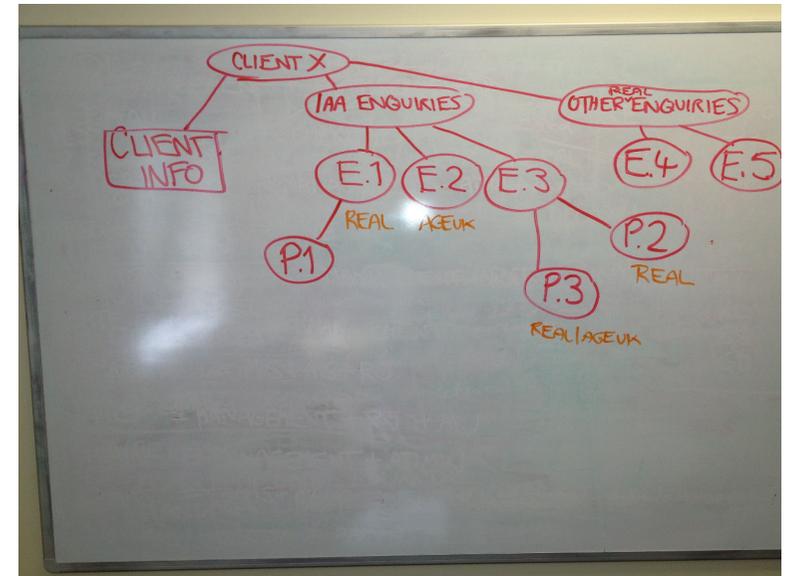
Figure 29: Permissions diagram produced by Real team

A key organisational milestone occurred near the end of this phase with a meeting, on 13th September, when Hublink was presented to all of the consortium partners for the first time. The whole development team: Paula, Kate and myself were invited to attend. As well as make a short presentation I adapted some of the scripts to allow the partners to try the application for themselves. This was a key moment in the acceptance of Hublink by both *Real* and the partner organisations as their shared infrastructure.

On October 17th a technical milestone was reached when I installed the application onto the production server. This marked the end of the main development phase and transitioned the project into its "soft launch". Hublink's permanent home was to be on a server managed by a commercial company who are a strong user and supporter of Open Source solutions. This company were to be responsible for backups, server level security and ongoing server maintenance. The contract with Bytemark was with *Real* and Fossbox, as manager of the project from the technical side, was keen that they should take ownership of this relationship. To that end, I did the installation work on-site at *Real* together with the Operations Manager who was to take charge of this relationship. Doing this work together was motivated by our priority to transfer ownership and control to the community partner, as emphasised by researchers in CI, for instance Merkel et al. (2005) and Gurstein (1997). Meanwhile the capacity to do so illustrates the point by Burt and Taylor (2001) that effective deployment of IT systems in VSO's is highly dependent on the presence of staff with the correct expertise. Compliance with data protection legislation was specified and overseen by the Operations Manager and included features such as forced password rotation for users, forced logout, a strong firewall and encrypted connection with the server (SSL). This part of the process also surfaces the important point that even if a solution is based on FLOSS, it is not ever free of cost as there always needs to be infrastructure in place to run the system.
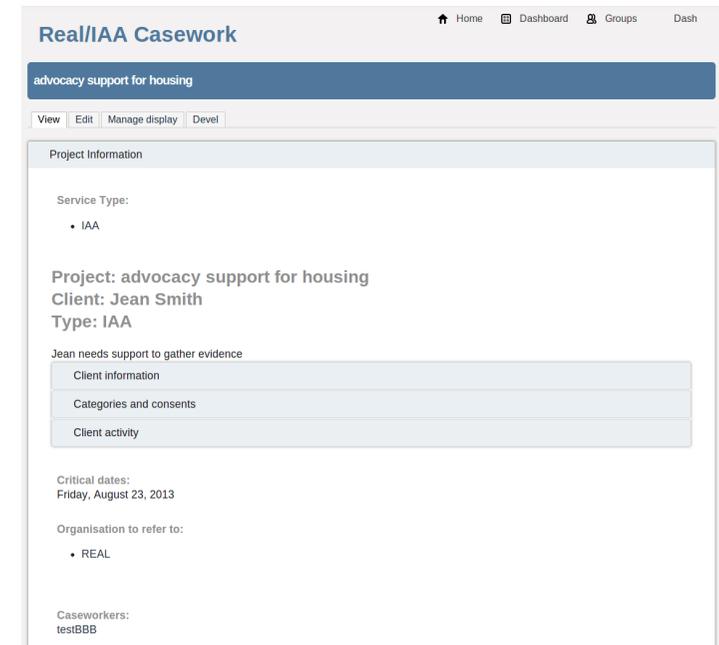
Figure 30: Project view in iteration 3

With the resolution of the groups and workflow issues and the acceptance of the system, at least in broad terms, by the project partners, , the main body of the design and development process was concluded. However, in our case, this was by no means the actual end of design. After the reflections on this phase, we move on to phase 3 in which the system transitioned from design into use.

5.2.6 Reflections on Phase 2

5.2.6.1 Having a say

In Phase 2, as in phase 1, PD methods were chosen because they facilitated a rich exchange of information. Like our use of paper prototyping described in the previous section, the use of scenarios and working prototypes in this project were chosen because they were consistent both with PD values and would facilitate collaborative working and recognition of expertise at all levels of the organisation. We found that they did indeed succeeded in providing an effective, as well as a streamlined and pragmatic, route to having a say. (Textbox 10). We also found that the scenario-based methods were useful in our specific context because they could provide specifications for the project without relying on prior experience of managing technology projects on the community partners' side, and could accommodate different levels of confidence with using computers.

The role playing exercise in iteration 2 making use of the working prototypes facilitated the fleshing out of fine details such as the exact the fields required for information and the workflow, as well for Kate the front end developer to start to develop the user interface.

In terms of the tools that you used… Those exercises where you came in and you did stuff, when you said click this, do that, do the other, I found they were a really rich learning experience - ah I see what you've done now, no you can't do that and they were really good… I think that was a very rich exercise in terms of how quickly we could to see what needed to be different and how much you could learn from us at the same time. **Mike Smith 9 April 2014**

Textbox 10: Reflection on iterations 2 and 3

The workshop activities in both iteration 2 and iteration 3 quickly revealed the large volume of granular information that needed to be gathered from clients. Consequently, at this point, the challenge for the user interface design emerged clearly (Textbox 11). In considering possible design solutions, we found that the role-playing exercises gave us useful guidance. For example, a possible solution for long, complicated forms under consideration was a guided, multi-step form. However, from the role-playing scenarios we discovered that gathering information from clients in advice work is a non-linear process where information may be given at any point. Therefore, we realised that it was important to also be able to enter information at any point and we quickly concluded that a multistep form would not work in this context (Textbox 12).

Reflecting on these workshop and testing sessions from a PD perspective, it emerged that the chosen methods facilitated having a say and mutual learning very effectively. The development team learned more about the work at *Real* and how it needed to be recorded in our system, and in the meantime staff at *Real* gradually built familiarity with the basic constructs of the system, and the kind of things we needed to know to address requirements and problems. Added to that, the whole group gained insights into the issues around consortium working, even though we were missing participation from other consortium members at this point. This illustrates the effectiveness of PD methods in facilitating the mutual learning process that has gone on to be so crucial in the long term sustainability of the project. Going beyond this, our activities reflected Muller and Druin's concept of a '3rd space' in which experiences are shared and creative solutions emerge (2003). Very significantly, though hard to quantify, the group reflections also showed that these shared tasks helped to build trust and understanding between the development team and the community partners. As also observed by Parra et. al., trust is an essential if under-recognised enabler for a long term participatory process (2015) and therefore key to

Its dealing with an issue that a lot of websites aren't which is that its collecting a lot of information and needs to present that in a way that's easy and that people access. So many different fields was something we really battled with. and we tried a lot of different approaches because that's a really complex system. **Kate Lomax 9 April 2014**

Textbox 11: Reflection on dealing with complex data entry

Some people were reluctant to role play but some had a lot of fun with this aspect. One staff member from Real immediately launched in to acting out a loquacious client with a complicated set of benefits, health problems and complaints. It was a playful and empathetic moment which showed us immediately that information comes in to a worker in a non-linear, disorganised form and, like advice work itself, our application would need to deal with multiple entry points to a problem.

Textbox 12: Self-reflection from scenarios 1

sustainability.

After the group workshops based on the iterations, the PD principle of "having a say" remained a guiding principle but was more difficult to fulfil through PD methods. Before this point PD methods were invaluable in enabling feedback and conversation that bridged roles in the development process. However they were less useful for facilitating the next stage of discussion, which demanded systematic thinking, tackled thorny issues, and had a need for precision. The challenges around communicating this thinking sometimes led to tension (Textbox 13). Though we did not apply any defined methods at this point, ad-hoc collaborative and creative strategies played a part in problem solving attempts both among the development team and *Real*. For example, one of the most complex features of Hublink is its control of visibility of data between organisations and teams. Data can be shared between teams on the basis of client consent, and even then, certain fields need to remain hidden until a caseworker is allocated. While I tried to puzzle through the detail of the problem and possible implementations through schematic, visual representations, the team at *Real*, working independently from from the development team, evolved their own method, using scenarios to think through variations of the problem and coming up with a visual expression of these (Figure 29).

As things worked out, all the different needs could be catered to via the configurability of the Organic Groups module and some custom code that automatically added content to the correct group following some quite straightforward rules. Moreover, after launch some adjustments needed to be made because of different corporate policies of the partners. Though complex, the groups and permissions part of the system has remained robust through the life of the project,

Figure 31: Horizontal tabs: can be clicked to reveal more information or form fields

That whole process was really really difficult; partly because you see things visually, I see things in lists, and Mike sees things in longer lists! Doesn't he! (*all laugh*). He's all about words, and we were the three of us coming from quite different places. It took a long time to actually get past that, but i think we've done it and I think it actually does work. **Cathie Duncan 13 March 2014.**

Textbox 13: Reflection on working out group visibility

perhaps because of the level of focus from all participants at this early stage, and certainly because of the ongoing configurability of the system while in use. This robustness illustrates the value of the FLOSS software dynamic in which tailorability is developed in response to the shared needs of the community who use the software.

The lack of a completely stable group of participants throughout the process was not an ideal situation. At the time, this did not seem to be a major barrier to progress (Textbox 14), but in retrospect a view emerged that it disadvantaged the project (Textbox 15). Literature from CI provides insight on the constraints faced by community organisations, where workers prioritise frontline work (Burt & Taylor 2001) . Added to this, in disability organisations workers may be more likely to be part-time as flexible work is an important way that the organisations' workforce can better represent the communities that they also serve (Disability Rights UK 2015). The problem of working under tight constraints is expressed in the reflective interviews, for instance Textbox 17.

5.2.6.2 Co-creation and mutual learning

Co-creation, together with mutual learning, is the distinguishing marker of PD in contrast to other forms of UCD (Bratteteig et al. 2012). In the Hublink project we saw co-creation as an important way to facilitate knowledge distribution and shared ownership as well as solve design problems.   To explore the dynamics of co-creation and mutual learning in the context of this project, the evolution of the dashboard, together with the critical dates and action dates features, were used as discussion points in the reflective interviews. The dashboard was a design contribution that came, at first, wholly from the development team and was presented to the frontline workers for the first time in iteration 2. Its initial intention was to meet core

At first I was a little disappointed that we did not have a stable team of front-line workers attending every meeting. But I soon realised this was impossible given people's busy schedules and often part-time hours. As things worked out, people appeared at different parts of the process and it was interesting to get feedback from, for instance, a front-line worker who had been at the initial workshop but who we did not then see again until iteration 3.

Textbox 14: Self-reflection on iterations 1 and 2

I think in truth that it would have been better if one person had been in the process throughout. I don't think that was possible or appropriate in the circumstances… but you probably would have benefited and we would have benefited if someone working on it at this stage had been working at it all the way through. **Cathie Duncan 13 March 2014**

Textbox 15: Reflection on constraints on participation

requirements that had emerged through the initial workshop, such as the triage of incoming referrals. It was also intended to start a design process around managing the large amount of information what individuals would have to work with. The dashboard concept was not, at first, easy to get across to frontline workers, which was a surprise to the development team. This showed that while for developers the dashboard concept felt very intuitive, probably stemming from our familiarity with content management systems such as Wordpress or hosting interfaces such as Cpanel, the frontline staff did not share these reference points. Nevertheless, as the discussion of this feature progressed the whole group started to reach a better understanding. After some discussion, frontline workers conceptually linked our idea of the dashboard with their use of desktop organisational tools, especially calendars. Though were not be able to integrate with Microsoft Outlook calendars - the software used by the teams - technically, this conceptual link did provide a starting point for developing shared ideas about how the dashboard could be most usefully laid out and what features it might have. It was at this point that the features of 'action dates' and 'critical dates' were fleshed out by Project workers, as the dashboard started to be understood as an organising tool for each individual. By iteration 3 the dashboard had begun to move forward as a collaborative project between designers and users, which was prototyped into the next stage and further refined by project workers throughout the transition and design in use periods. From this point on, feedback about the dashboard has been mainly positive (Textbox 16), and there have been many contributions from *Real* staff members to its ongoing refinement.

Mutual learning was strongly reflected in the consortium partners' meeting in which the technology was presented with confidence by the community partners who projected a full sense of ownership and understanding of the technology to the other consortium partners partners. This is evidence of the observation by Carroll and Rosson that the ability to be in

Particularly in a small organisation, this is only one element in a bigger project which is actually only one element of a whole organisation and there were times when we just couldn't devote the attention it needed to work as well as it should have done. That's just the reality of the day job. **Mike Smith 9 April 2014**

Textbox 17: Reflection on organisational constraints

I do like the dashboard because that's new, i haven't come across that on any other system. thats quite good because you can see your clients and who you've recently worked on and quickly jump on finding the clients. i quite like that bit. And when you look at your client you think - oh yes I must call that person. **Real Advocate 26 March 2014**

Textbox 16: Reflection on the dashboard by frontline worker

135

control of technologies increases the sense of ownership people have over them (Carroll & Rosson 2007), and the general aim of PD to facilitate ownership and control (Dantec & DiSalvo 2013) . This presentation and the sense of ownership expressed by the partners (Textbox 18) can be seen the beginning of the process of adoption, in which the system is more widely accepted among a greater group of users. Through the confidence and sense of ownership expressed at this meeting, the relationship between mutual learning and adoption was illustrated and the benefit of PD to the adoption process manifested.

It feels like our database. it doesn't feel like we've bought advice pro or something. It feels like ours.
Karen Linnane 13 mar 2014

Textbox 18: Reflection on ownership

5.2.6.3 Infrastructuring

Infrastructuring is one of the main themes of this research and it is at this point that infrastructuring starts to become a useful frame of reference in our case study narrative.

A strong feature of work in this phase was the large extent that our workshops became opportunities to work out the mechanics of the consortium service as a whole. This was particularly true of the workshops for iteration 3 where the staff who would be running the consortium were coming on board. During our meetings during this phase, discussions were frequently sidetracked into deep and detailed debates about how work processes would transform once consortium working was underway. This echoes the observation from, among others, Beyer and Hotzblatt (1997) that the design of an information system inevitably goes hand in hand with 'work-redesign'. PD suggests that there should be an inclusive approach to which problems are solved and how (Bratteteig et al. 2012) and this principle guided our sense that it would not be appropriate to shut down wider conversations about work re-design for the sake of focus on the information system, and it felt clear that this conversation was needed

The mood changed slightly as new staff had come on board who were actually going to be responsible for the delivery of the service. The walkthroughs were effective, but got stuck at points as long debates started about how exactly things like referrals and allocations of caseworkers were going to work in practice. We did not stop or limit these discussions as they were clearly crucial to the overall working of the new service even if not strictly relevant to the application.   A level of anxiety has crept in as the launch of the actual service draws closer, and we all realise what a big task we have taken on and how much rides on it.

Textbox 19: Self-reflection on work-redesign discussions

among our partners (Textbox 20). This intertwining of working out the system in tandem with the service also strongly reflects the value of the infrastructuring perspective with its recognition of the inseparability of organisational, human and technical factors (Neumann et al. 1996; Pipek & Wulf 2009; Karasti & Syrjänen 2004). Therefore, from an inclusive perspective, the scenarios and scripts can be seen as effective tools to provoke ideas and discussion on broader issues as well as refine the information system.

As a development team, we were also keenly aware that we had not got feedback from front-line workers at the paper prototype stage so we saw this wider discussion as an important chance for frontline workers to have input and get to know them better. These discussions also highlighted that it would be impossible for all the processes to be fully worked out before the rest of the partners started to work with the system, and therefore that tailorability was going to be extremely important for the success of the project.

It turned out that the team at Real were very skilled at recognising when their discussions were about the consortium and where issues were arising that were to do with the system. They were quick to reassure us, especially when disagreements broke out. The sessions were very intense, and sometimes uncomfortable, and I was very grateful these insights that saved a lot of stress and tension and kept me focussed on the system.

Textbox 20: Self-reflection on iterations 2 and 3

Following on from the iteration 2 workshop, for iteration 3 a design principle was adopted that unnecessary information should be hidden, but signposted. Horizontal, accordian style tabs were used to do this (Figure 31). In Drupal, this has the benefit of being a highly tailorable solution as the tab labels and the groupings of fields beneath each tab can be edited via web interface, and therefore potentially can be altered by advanced users. For example, in Figure 32 the blue horizontal bars are the clickable tabs that reveal further information ('client activity' is here shown open), and their texts are easily editable through the Drupal web interface by non-programmers. This tool was extremely useful in our situation, in which there was clearly going to be ongoing change, and also that there was the potential for terminology to vary across organisations as they came on board. In other words, the ability to further customise when the

partners were fully on board was going to be very important to facilitate the wider adoption of the project in view of the limitations of partners' participation in the design phase.

The other more obviously infrastructural aspect of Hublink is its hosting. For this project, Fossbox recommended working with the company Bytemark who provide an affordable managed hosting service, based on open source tools. Bytemark are responsible for uptime and backups, and the aspects of security that can be said to be part of the infrastructure. From the beginning we were anxious that *Real* should 'own' this relationship, that is, that they should have a contract directly with Bytemark and a direct channel of communication with them. This would give them independence from the development team, allowing them choice and control over who should look after their application going into the longer term, and control over issues such as disaster recovery, data protection and security that are legally part of their duties. This ability to exercise choice and control is emphasised in writers in CI such as Gurstein (2015) and Gurumruthy(2015). This part of the infrastructure also shows how FLOSS systems are interdependent with commercial services, and while can provide affordability, do not or should not imply zero cost solutions.

In move that reflects both co-creation and infrastructuring, sometime around this time the application the system acquired its name - 'Hublink'. The name was coined by a new staff member at *Real* and accepted happily by all. The title refers to the consortium's service delivery being focussed on a series of advice 'hubs' – drop in points in the consortium members' premises that are distributed geographically and by interest group around the borough.
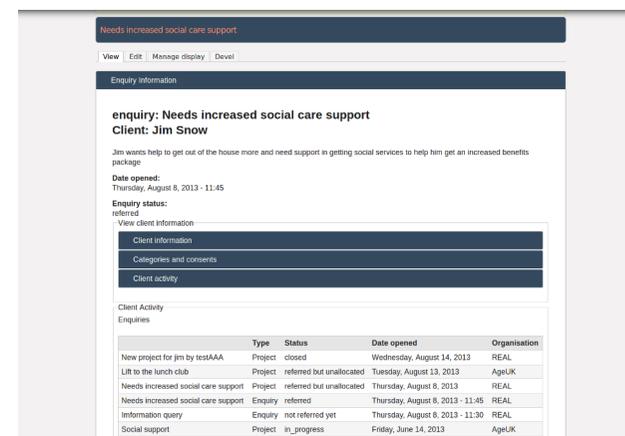
Figure 32: Enquiry screen after iteration 3

In phase 2 the theme of 'having a say' decreased in prominence as the project has progressed. Meanwhile the themes of co-creation and especially mutual learning started to emerge strongly from the case study narrative and their benefits to the later stages of the project began to surface. The next section traces this next chapter of the story, in which the theme of 'having a say' remains significant, but in which the themes of 'mutual learning' and 'co-creation' come more into the foreground.

5.3 Phase 3: Soft launch

5.3.1 Timeline

Deployment to server

launch in test to all partners

Full launch

Soft launch

Workflow documentation agreed

Creation of users and groups
Tests in live environment

Elearning completed

Sep '13   Oct '13   Nov '13   Dec '13   Jan '14
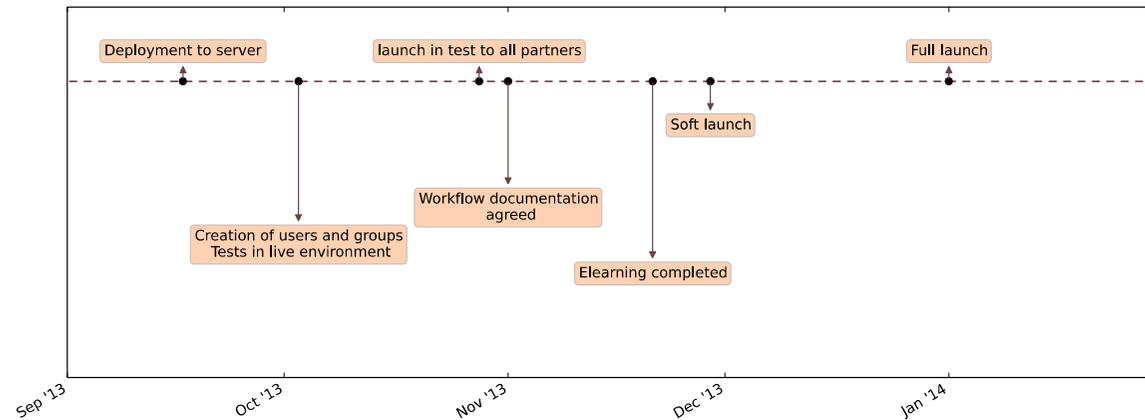
Figure 33: Timeline, phase 3

5.3.2 Overview

Phase 3 covers a relatively short period of time but represents a crucial moment in the
development of Hublink. This phase stretches from just after deployment into the production
environment and the final tests as described in the previous section, to the moment that Hublink
is put fully into production, that is, when consortium partners are expected to use it to record all
of their work. The beginning of this phase corresponds to the launch of the consortium on 1
October 2013, and ends with the end of the calendar year 2013. During this phase, staff at *Real*

and the consortium partners were asked to start inputting records to Hublink, but also to keep their old system in place. Both the development team and the *Real* staff thought that a 'soft launch' period would be beneficial to the project. It was important that the application should be used by at least some people as if it was integrated into their everyday work practice but without the pressure of it being the single repository of records. This soft launch can therefore be seen as a 'transition phase' between development and production, in which the application is thoroughly tested, any bugs and serious usage problems ironed out, and generally made ready for its final conditions of use. The term transition phase is here borrowed from the Unified Process model of software development (Kruchten & Philippe 1998) as it accurately describes the work required to move from development to production, including making the application available in its production environment and preparing end users. However in our case there is a major difference, as in this project it is not the last phase of development. In our flexible and and participatory model this phase is not the end of development, but transition into design in use with different patterns of development.

Row	Benefits	Employment	Financial advice	Health	Housing	Leisure	Other	Social care	Travel	Volunteering	Total
Age UK East London	0	0	0	0	0	0	0	0	0	0	0
Alzheimers	0	0	0	0	0	0	0	6	0	0	6
APASENTH	0	0	0	0	0	0	0	0	0	0	0
BbBC	0	0	0	0	0	0	0	0	0	0	0
deafPLUS	1	0	3	1	0	0	0	0	0	0	5
Mencap	0	0	0	0	0	0	3	4	0	0	7
Positive East	4	0	0	1	1	0	0	0	0	0	6
Real	1	1	1	0	3	0	2	3	0	0	11
THLC	2	0	0	0	0	0	0	0	0	0	2
Total	8	1	4	2	4	0	5	13	0	0	37

Figure 34: Issues open during the transition phase

This phase was divided roughly in two. During October and most of November the project was still in test phase, using placeholder content. On 28th November all test content was deleted and all consortium partners were invited to start record keeping on Hublink. In this busy and sometimes stressful phase, the knowledge and trust that had been built up through the PD process became an important resource, enabling the team to identify issues clearly and problem-solve together. Notably, evidence shows that the design work we did together in earlier phases facilitated the *Real* team in taking full ownership and responsibility for the training and documentation for the other community partners.   Indeed one of the most remarkable features of this phase was the emergence of the consortium's project co-ordinator as a leading user who

increasingly took on a role of mediating and requesting changes and refinements from her own knowledge and from her team, and carrying out the adoption tasks – training and documentation – needed to get ready for Hublink's launch as the consortium's main infrastructure. (Textbox 21). The project co-ordinators emerging role resembles the 'gardener' role described by Nardi (Gantt & Nardi 1992), especially in the way that she emerged as a specialist from her role as a domain expert rather than through any special recruitment process or plan. I have referred to her as a leading user to distinguish from Von Hippel's notion of a 'lead user' (Hippel 1988) in which lead users are identified and instrumentalised to drive innovation. In contrast, the gardener role can be more emergent and focussed toward facilitating the needs of peers in everyday work. This therefore better describes our situation.

I feel that Cathie has had the most input, and the most input in making it real for people who are going to use it. We are very conceptual and I think Cathie has made it what people can actually get on with and use and understand. **Karen Linnane 13 mar 2014**

Textbox 21: Reflection on leading user role in the transition phase

5.3.3 Refinement

The design and testing phase had built up a small number of users who were already familiar with Hublink and also knew the developers. These were an ideal group to be the core users in this soft launch phase. On one hand they would be likely to know the expected behaviour of the system and on the other, through the previous face to face contact with developers, there was a good relationship in place that would help communication. Individuals from this group also had a key role in mediating questions from the consortium partners who gradually started to enter their data on Hublink. They therefore could be said to be forming the beginning of a community of practice (Wenger 1998), based on the experiential learning (Kolb 1939- 1984), gained through the PD process (Bratteteig et al. 2012).

Though this was a busy stage, the minority of development work was on new features. Most of the work was on refining the features that were in place to make them fully fit for purpose. This included refinements in the infrastructure and security features such as mandatory password complexity and rotation and automated logout. The workflow and group allocation features were also double-checked and refined where necessary. A number of usability improvements were needed, including quite a number of tweaks to tools that are heavily used by frontline workers such as the dashboard (see Textbox 22 for an example on how this developed at this stage) and the client search facility. An expanded amount of error handling to encompass more error conditions was also included.

In a work-based application such as this visual design plays just one part of many in making the application usable. As Neilsen (1997) points out, text elements such as field and button labels are key to making an application navigable and learnable by users. By this transition phase, the emerging leading user, the project co-ordinator of the consortium based at *Real*, began to take on this kind of work herself; instead of asking developers to to these tasks, she began to ask how she could do them herself. Drupal, with its web-based configuration is able to facilitate this kind of customisation via its web front-end (For example, Figure 35). As discussed in more detail later, evidence shows that her ability and willingness to do these tasks was a direct result of the PD process.

Hi Lisa,

You asked me to let you know what I need to see on the dashboard. Karen and Mike, please feel free to add your comments/additions. As discussed, filters would be needed to manage this. The primary filter needs to be the organisation with the following secondary filters in date order (most recent first):

-number of open enquiries / projects

-unallocated referrals (by internal service for Real i.e. IAA or ILS)

-allocated referrals

-whether casework has commenced on an allocated referral

-key dates and critical dates

-referral follow-up dates

Thank you for yesterday, it was really helpful. It's great to see the database evolving.

Best wishes and enjoy your holiday.

Textbox 22: email about the dashboard from the project coordinator during transition phase

Label	Region	Name	Field	Widget	Operations
Content					
✛ **Projects group**	Content ▾	group_projects_group	Accordion group ▾	**classes** group-projects-group field-group-div form... **effect** Bounce slide	⚙ delete
✛ **Project information**	Content ▾	group_project_information	Accordion item ▾	**accordion-item** open **required_fields** yes **classes** group-project-information field-group...	delete
✛ Service	Content ▾	field_service_delivery_type	Term reference	Check boxes/radio buttons	delete
✛ Project title	Content ▾	title	Node module element		
✛ Client	Content ▾	field_client	Entity Reference	Autocomplete	delete
✛ Critical or important dates by which work must start on this referral or the referral must be accepted	Content ▾	field_critical_dates	Date (Unix timestamp)	Pop-up calendar	delete
✛ Project description	Content ▾	body	Long text and summary	Text area with a summary	edit delete
✛ The organisation that will work on this referral	Content ▾	field_organisation_term	Term reference	Select list	edit delete
✛ **Project contacts**	Content ▾	group_project_contacts	Accordion item ▾	**accordion-item** closed **required_fields** yes **classes** group-project-contacts field-group-accordion-item	⚙ delete
✛ Caseworkers	Content ▾	field_project_caseworkers	Entity Reference	Autocomplete	edit delete
✛ **Case notes**	Content ▾	group_project_notes	Accordion item ▾	**accordion-item** closed **required_fields** yes **classes** group-project-notes field-group-accordion-item	⚙ delete
✛ Notes	Content ▾	field_project_notes	Entity Reference	Inline entity form - Multiple values	edit delete
✛ **Categories and Consents**	Content ▾	group_consents	Accordion item ▾	**accordion-item** closed **required_fields** yes **classes** group-consents field-group-accordion-item	⚙ delete
✛ Domains of service/ issue	Content ▾	field_domains_of_service	Term reference	Check boxes/radio buttons	edit delete
✛ Other service	Content ▾	field_domains_of_service_other	Term reference	Autocomplete term widget (tagging)	edit delete
✛ Consent	Content ▾	field_project_consent	List (text)	Check boxes/radio buttons	edit delete
✛ Special instructions about consent (variation on consent)	Content ▾	field_project_consent_variation	Long text	Text area (multiple rows)	edit delete
✛ Teams who can see this record	Content ▾	og_group_ref	Entity Reference	OG reference	edit delete
✛ Access to this record	Content ▾	group_content_access	List (integer)	Select list	edit delete
✛ **Project administration**	Content ▾	group_project_administration	Accordion item ▾	**accordion-item** closed **classes** group-project-administration field-group... **required_fields** yes	⚙ delete
✛ Source of referral for project	Content ▾	field_referral_source	Term reference	Check boxes/radio buttons	edit delete
✛ Project source - other	Content ▾	field_enquiry_source_other	Term reference	Autocomplete term widget (tagging)	edit delete
✛ How did the client hear about the service?	Content ▾	field_how_hear_about_service	Term reference	Check boxes/radio buttons	edit delete
✛ How did the client hear about the service - other	Content ▾	field_how_hear_about_service_oth	Term reference	Autocomplete term widget (tagging)	edit delete

Click 'edit' on any Field to change help text, label or required status

Scroll down for more fields

Figure 35: Documentation on how to change the input form for projects. Other content types configuration are similar

144

5.3.4 Training and documentation

Moving beyond the refinement of the actual application, a crucial activity during this phase was the preparation of documentation and learning materials. Again, as a result of the high level of mutual learning that took place through the design process, this was wholly taken on by the staff at *Real* (Textbox 23).

Work on documentation began immediately after the testing sessions that marked the end of the development period and was undertaken by the project co-ordinator and Operations Manager. They produced 'elearning' packages of consisting of presentations and videos for people in partner organisations to use independently, supported by a glossary of terms. The e-learning materials consisted of 6 screencast style videos with commentary and accompanying slide presentations. These are available in their entirety as accompanying material: 1 - Elearning . These were designed to both be used by partner organisations independently and to form the basis of face to face training workshops delivered by the project coordinator. The production work on these took place without any participation from the project team, except for the occasional request for clarification.

The detailed work necessary to produce these materials had other beneficial effects. Of necessity, during this work, the functionality and interface of Hublink were examined in minute detail by the users. Many corrections and additions arose which were passed on to the development team in a steady stream of emails. The characteristic of these exchanges was the high level of detail, shared understanding and co-operative approach which can also be

We've been able to deliver Hublink to the other partners, and we've been able to train them up on it and give them information on it and get them on board with using it, because we've been involved in designing this and we understand it. if this was something that was just given to us i don't think we'd be able to impart our learning and training and understanding in the way that we have. **Karen Linnane 13 March 2014**

Textbox 23: Reflection on the transition phase

attributed to the Mutual Learning outcomes. Overall, this transition phase showed a level of knowledge, engagement and interest in the application that surpassed all our expectations and allowed genuinely collaborative working across the development team and community partners. With this project a great deal was achieved in a short amount of time and as a whole group, our capacity was greatly enhanced by this ability to work together through shared language and negotiation. (see for example the exchange in textbox 24).

This reflects Bishop and Bruce's definition of CI in which working together toward shared aims and the necessity for developing learning and skills are defining features (Bishop & Bruce 2006). A coming together of individuals' broader experiences was also observed, beyond the knowledge that is associated with their current job role. For example, *Real* CEO Mike Smith's education in computer science was felt by him and others to be significant, even though he did not explicitly use that knowledge in his role. The project co-ordinator had formerly been and Advice Worker and myself, as developer, had much experience of working within VSO's . This reflects the notion of PD as a productive and creative 'third space' which encompasses many experiences and perspectives (Muller & Druin 2003).

On the negative side, as will be explored more in the reflective part of this phase and in later phases, the volume and type of work was unforeseen. This, together with the heightened level of responsibility that comes with a custom rather than off the shelf system, caused everyone working on the project a high level of stress.

Cathie: One thing that has come up this afternoon with an advocate though is the fact that it may not practical for Managers to be the only ones that can allocate caseworkers to projects. Our advocates are likely to set up a number of projects whilst working with a client and it interrupts their workflow if they have to wait for me to allocate any project they create. I'm going to give this some thought over the weekend as I'm not sure yet the way round it.

Lisa: Technically, its perfectly possible to allow project workers to allocate caseworkers. The only issue is that in allocating a caseworker access to the record is opened up to the newly allocated
caseworkers team, so its a matter of trust. I could see if I could do something like project workers can allocate caseworkers, but only ones in their team (this would include themselves).

Cathie: That would be perfect - caseworkers can allocate within their team only (in fact these should be the only options to appear). We already discussed previously the fact that within teams, confidentiality will be shared and I think that extends to this. It would be useful to have a record of allocation history for each project, in case it changes whilst the project is open.

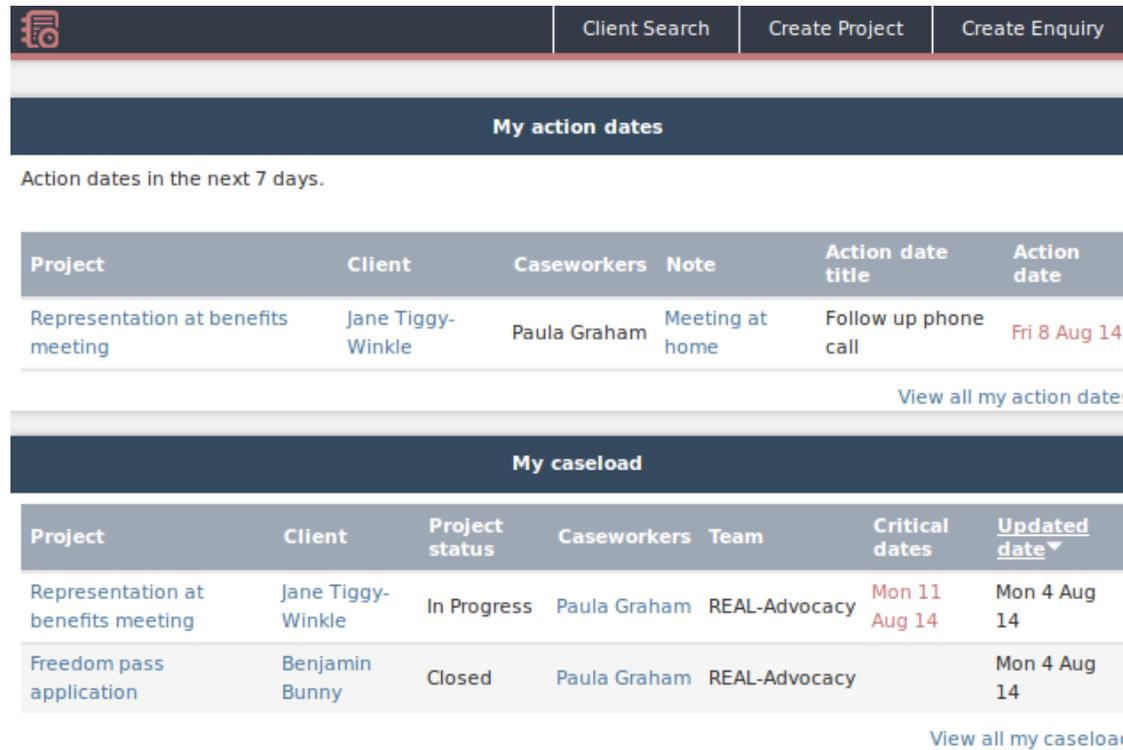*Textbox 24: Negotiating refinements email, Email extract, 18-20 oct 2103*

Figure 36: Dashboard - final version showing critical and action dates

5.3.5 Reflections on phase 3

5.3.5.1 Mutual Learning

It is in this phase that the mutual learning from the PD process is observed to show concrete
benefits to the the project as a whole, beyond design tasks. Most notably, all of the

tasks related to the adoption of the software among the partners: which consisted mostly of training and documentation, was undertaken entirely by the community partners. While the development team were asked to check materials, we did not have to produce any ourselves, or go to site visits to the partners. This was a surprise to the development team and it was a very gratifying phenomenon to observe. My curiosity was aroused as to how this degree of knowledge had come about and whether is was connected to the high level of involvement during the design phase. Reflections from the staff involved provided evidence that this high level of knowledge was indeed a result of involvement in earlier stages of the design. (See textboxes 25 and 23). Moreover, beyond concrete training and adoption tasks, mutual learning also provided a basis with which the project coordinator and I could manage the high level of demand that was being put on us. By working as peers and having a shared understanding of the application in context, as a developer I was able to negotiate solutions to problems that both met the needs of the organisation but were realistic and economic to implement and would keep the risk of instability low. It was this ability to negotiate the changes, refinements and enhancements that was, for me, one of the distinguishing features of this project. Such negotiation is rarely possible in a commercial client and provider relationship, and I suggest has a stronger resemblance to the 'informalities' (Scacchi 2002) or 'provisionments' (Alspaugh & Scacchi 2013) found in FLOSS projects than the formal processes of digital project management.

A key feature of this phase was also the emergence of the Project Co-ordinator as the lynchpin of the project, developing a role in which became the prime connecting point between the domain of the consortium and its advice and advocacy work and the concerns of the information system development. She was able to channel and translate concerns and issues from either

I used it as the basis of the training sessions that I did. it was time-consuming to do the practical aspect of it, but the actual writing of the elearning was very straightforward and that was because of being involved in the development process . **Cathie Duncan 13 mar 2014**

Textbox 25: Reflection on the e-learning

side, and undertake adoption, support and customisation work herself. Though unplanned, this role was crucial in the success of the project and evidence shows that this emergence was due to the mutual learning gains from the PD design process. I am using the term 'leading user' for this role, to distinguish it from the definition of 'lead user' from Von Hippel in which certain kinds of users are recruited for the explicit purpose of driving innovation or adoption (Hippel 1988)

5.3.5.2 Co-realisation

Illustrating the effect of mutual learning on the adoption phase and how it blends with co-realisation, the email exchange in textbox 24 illustrates how the leading user at *Real* adopts a role in which she mediates the contributions of others and makes creative contributions. This role shows elements of the 'implementation mediator' role that is promoted by the HISP project (Shidende & Mörtberg 2014). In this phase, co-realisation also started to blend with customisation as the leading user began to not only think up refinements but to want to implement them as well. It could be said that she 'crossed the point of infrastructure' described by Wulf and Pipek (Pipek & Wulf 2009) where she transitions from using to customising the technology.

In another example of both mutual learning, co-creation and this mediator role, the project co-ordinator continued to refine the dashboard specification, drawing in direct input from frontline workers. As discussed in phase 2, the dashboard was intended as a personalised control centre for peoples work, and had the aspiration to strengthen administrative processes such as allocating new referrals to caseworkers and ensuring that cases are acted upon in an appropriate

time frame. The Dashboard is therefore crucial to to the functioning of the consortium as well as providing a personalised area that helps people organise their work. During the transition phase several revisions were made to the dashboard that came direct from frontline workers, including improved views for 'critical dates' , enquiries and sortable columns. In this an increasing sense of ownership through participation is observed, that itself encourages greater participation .   See Figure 36 for how these features can be seen on the finished dashboard. Yet another area of collaborative and creative work was around documentation.   A great challenge was in expressing the finer points of the system – namely groups allocation and workflow – in ways that were digestible and understandable.   As has already been discussed, visual communication was used where possible to achieve clear communication and circumvent the production of huge amounts of paperwork. This principle to use visual and creative means was continued into the documentation phase. It was not always easy to achieve the kind of succinct communication needed, and it was necessary to iterate over several versions. Figure 37 shows a version of my documentation, emailed, printed, annotated, scanned and sent back by the project co-ordinator as part of a collaborative, iterative process of improvement.
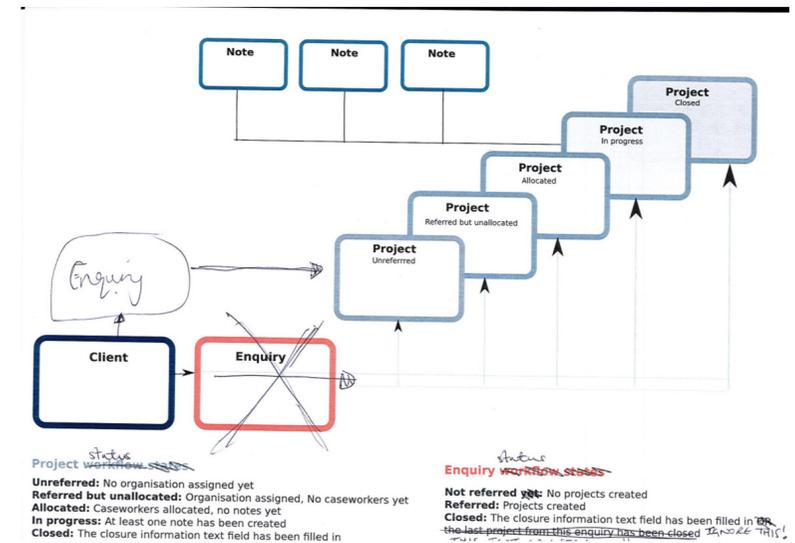
Figure 37: Documentation - sent, annotated and sent back

5.3.5.3 Infrastructuring: Appropriation and Tailorability

It was clear to the development team that this 'transition' phase did not mean the end of design but instead a transition into a new phase of 'design in use' (Henderson & Kyng 1992; Pipek & Wulf 2009), or 'design after design' (Björgvinsson et al. 2010; Bratteteig 2003). This was for at least three reason. Firstly, the continuous development of the service design with the information system remained a feature and details about consortium working were still not

stable. Secondly the partners were brought on board late in the design process. Thirdly, the all-important monitoring information required by the commissioner only began to arrive in November and December. This resulted in a flurry of activity to check that all the information required by the commissioner was indeed being gathered, and the addition of new fields where necessary. Simonsen and Hertzum (2008, 2012) note the importance of being able to adapt to changing environments , and this point has been amply illustrated throughout the lifetime of the project.

The FLOSS project Drupal was chosen for this project because of its dynamic extensibility and this decision has proved itself at this point in the process. Extensibility started to prove itself as the monitoring information began to be received and fields could be added or made compulsory to fill in through the web interface, without any manual changes to the code-base or database. Moreover, as skills and understanding grew among the design partners at *Real*, the flexible permissions system allowed developers to open new parts of the configuration interface to our collaborators. So, by the second half of this phase, the project co-ordinator was starting to edit and add categories, and make the user interface more suitable for use by editing the help texts and form and button labels; thus becoming an 'infrastructurer' (Pipek & Wulf 2009). The reflective interviews however, revealed a negative side to this degree of tailorability and participation. This is an increased sense of responsibility and pressure for the participants, and in particular for the project co-ordinator who had embraced Hublink as a key part of the consortium and her own work as its co-ordinator (Textbox 26). This pressure was not inconsiderable for our leading users and is certainly a lesson that, going forward, needs to be taken on board and more time, consideration and support given to users who are given or take on such responsibilities.

Its been positive in most ways, in terms of being able to ask it to provide us with the exact information that we want and need. I think as an organisation that comes with a lot of responsibility that you don't necessarily have when you buy a database off the shelf; if something goes wrong or if its difficult to use you can say, well, its not on our heads. **Cathie Duncan 13 March 2014**

Textbox 26: On participatory production

5.4 Phase 4: Design after design

5.4.1 Timeline
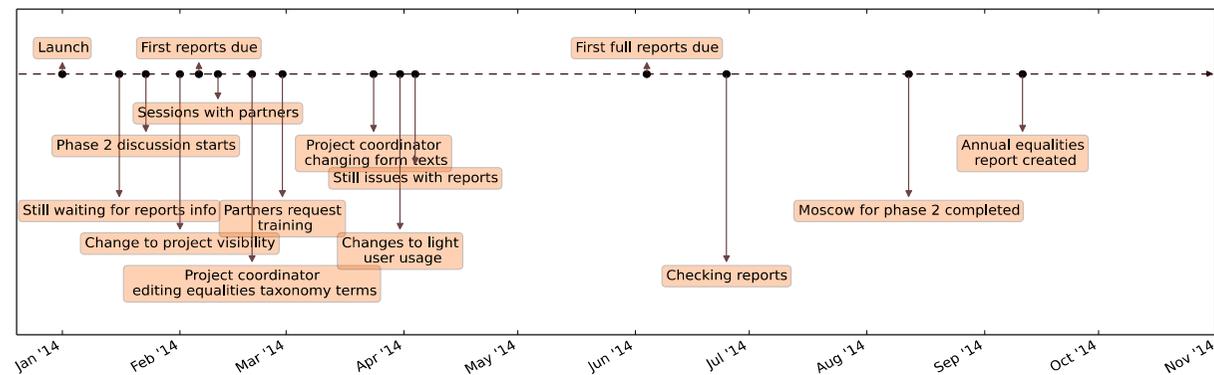
Figure 38: Timeline, phase 4

5.4.2 Overview

Phase 4 stretches from the launch of Hublink at the beginning of the calendar year to October 2014. This quite long phase represents the period where the application was used in earnest but there was still a substantial need for adjustments and enhancements. As the timeline shows, the first three months of use was a busy period, in which exposure to the other partners provoked many issues that needed response. This was a reasonable time to be making adjustments as the users were not yet accustomed to the interface and input from the other partners had not been possible earlier in the process. The end of the phase was marked by a slowdown in the need for changes, refinements and support.

For the consortium co-ordinator this was an extremely busy period in which she toured all of the consortium partners discussing how the consortium would work, and this involved showing people how to use Hublink. As has already been noted the development team were not needed in any of the training and adoption work. As discussed in the previous section, evidence shows involvement in the design process had provided the required depth of knowledge.

For a number of reasons which will be discussed later in this section, the partners were not involved before the launch (Textbox 28), and they had varied responses to Hublink. For a number of the partners it was slow and laborious for the consortium lead staff to encourage adoption, whereas others responded very positively . Throughout, the application itself proved technically robust - which can be expected given its basis in a well-tested open source framework. The workflow and group allocation which were the main custom features were technically sound. The refinements needed were mostly required to respond to feedback from the partners and the reality of the patterns of work that were unforeseen during the earlier phases.

This was also a period in which the reporting requirements were clarified from London Borough of Tower Hamlets (the commissioning body) and, because this was after the launch and the main design period, this had a substantial knock-on effect, extending the development period substantially and underlining the need for ongoing tailorability. This need to constantly keep abrest of change is in keeping with the observations from Simonsen and Hertzum (2008) . Although Simonsen and Hertzum's work discusses the challenges of 'large scale' systems, their work is resonant with Hublink because it is situated within the health sector which is subject to

It would have been really difficult to engage [the partners before launch]. I remember asking people to help and asking people if they could test, but then they didn't really do it. It was problematic both ways, because I didn't really have a good idea of what I was asking them to test. Its interesting/frustrating, because having been out on training sessions recently, people are coming up with fantastic ideas and input, but we needed this 5 months ago. And that's just frustrating because I feel that people have had plenty of opportunity to get involved. **Cathie Duncan 13 March 2014**

Textbox 28: Reflection on partner's involvement

I just tried to do one now and when i looked at all the tabs and you know, and it put me off *(laughs)* because, this is why i was reviewing now, when looking at it, a couple of times i'm thinking is a lot of it necessary? **Real Advocate 9 April 2014**

Textbox 27: Reflection on the large amount of data required

153

a large amount of changes and involves different institutions.

5.4.3 Training and Adoption

During January and February the consortium co-ordinator spent a great deal of time visiting partners and providing training on Hublink which turned out to be a difficult task. While some partner organisations found Hublink intuitive and liked using it, others, including some staff at *Real*, found its interface and terminology alien to their everyday practice, and found it tiresome to fill in the large amount of information required (Textbox 27).

The partner's situations were varied. For some Hublink was their first or only electronic record keeping system, while and for others they had to use it in parallel with existing systems. This led to unforeseen differences in the patterns of use of the system which, as will be discussed further, led to the need for changes and adjustments. It was also at this relatively late stage that other differences in the ways that organisations worked came more to light and therefore the extent to which the model of working in Hublink was dominated by *Real's* working practices became more evident. Some people found the terminology alien, and more subtle problems came to light as well, which is also reflected in Textbox 29. This set of problems refer back to the intertwining of service design and technical infrastructure. Staff at *Real*, having worked in detail on the application, were able to maintain a strong sense of differentiation between the work process shaped by Hublink and their actual work, but this was a challenge to other partners. This issue will be discussed later under the theme of appropriation. While the consortium co-ordinator felt that the preparation of the e-learning materials had not been useful for the partners, evidence shows that people did use it and like it. In addition, the project co-ordinator said that the process of making the e-learning, while time-consuming, helped in putting together the more personal, on-site training sessions that she delivered with consortium

There have been times when people have said, I have to do this, and then have to do this because that's what Hublink tells me to do, and I have to say of course that isn't the case. But they are so intertwined, when you look at that workflow you see that Hublink is describing a particular set of processes so as soon as you step out of sync with those processes, it throws up the question of 'what shall I do?' Its been quite interesting, challenging, to help people to understand that you can do things in a variety of ways, even if it doesn't quite follow the expected workflow. There was a bit of work to do with the other organisations to understand that those two things are separate, workflow and Hublink.
Cathie Duncan 13 March 2014

Textbox 29: Reflection on adoption and the relationship between the service and the infrastructure

partners (Textbox 25). It is also notable that the project co-ordinator was the first point of contact for all queries by the consortium partners related to Hublink, and her ability to answer most questions accounts for the low number of support requests received in this period. This is shown in more detail in the final part of this case study quantitative data from the development tools used in the project are analysed.

5.4.4 Essential changes

Although it was late to still be making changes, *Real* were keen to incorporate feedback from partners and, in a small number of cases, the issues raised at this point were essential for Hublink to be successfully incorporated into the work of the consortium.

For example: when partners gave their full attention to the information sharing aspects of Hublink it was found that the data sharing settings determined during development were too open to comply with the policies of some organisations (Textbox 30).   However, again, the configurability of the Drupal system, combined with the high level of understanding about how data sharing is implemented in Hublink, allowed this very important issue to be addressed quickly and easily in a way that was agreed as being very effective in the difficult and fluid circumstances of consortium working (Textbox 31).

I can understand the point of putting something in place so you don't have lots of duplicates, because potentially we could have clients that came to different organisations.   But i don't know how it got overlooked, that, from when we first talked about having some sort of shared work platform in particular one organisation always said; you shouldn't even see that that client is attached to us because we have such a specific area of work that if you know they are our client you know their health condition. So that should always have been the message... **Karen Linnane 13 March 2014**

Textbox 30: Reflection on the need for essential changes

I think the important bit is that you built in the flexibility so that Cathie could pin it down. **Karen Linnane 13 March 2014**

Textbox 31: Need for flexibility

Another important set of changes related to the different patterns of use in the organisations that had not been fully foreseen during the design phase. For example; in the original specification the start and end date of projects were automatically set when projects were created or when closure information was added. However this did not take into account the fact that many frontline workers add records retrospectively. Therefore a change was made to allow workers to access the start and end date of projects manually. Again, this was not a difficult change due to the tailorability of the system.

On a more substantial issue, it was only at this phase in the project that the whole group became more fully aware of how the 'full' and 'light' users might enter data into Hublink. While it had been foreseen that while some organisations would be using Hublink as their only case tracking system – 'full users', others already had different systems in place and would only be adding outline data to Hublink that was needed for reporting to the commissioner. Such users are termed 'light users'. A rough framework had been set up for this but which organisations would be light users, and how and when these organisations were going to be adding this data was not really clarified until this phase, when the application came into use and the attention of the partners had turned to it. (Textbox 32). See Figure 39 for the full and light users in the consortium.

On the other hand, features that were more fully worked up were not used as much as expected. For instance, while the referrals system from one organisation to another worked well technically, the frontline workers were more likely to phone their counterparts than to use Hublink for the full referral process because they felt that was a better way of working that would deliver a better service (Textbox 33). From an infrastructuring perspective, this could

The biggest input has been with people using it as 'light' version. thats probably the biggest area where thats not what mike thought itwould be like..... in reality, organisations were just not goign to fill in that level of detail **Karen Linnane 13 March 2014**
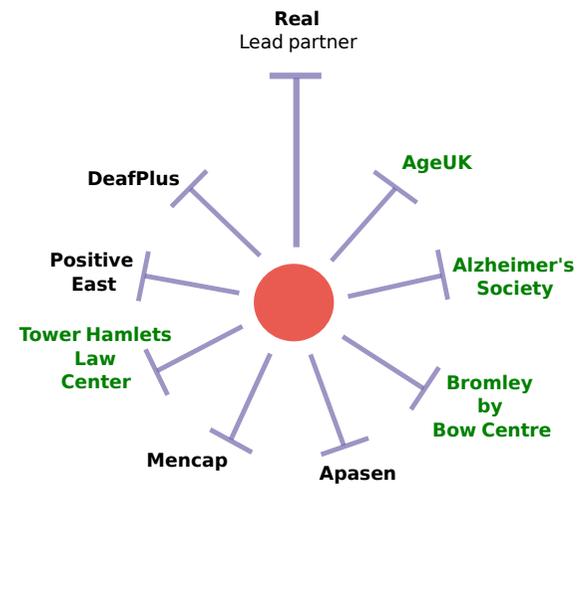
Textbox 32: Light users

Figure 39: Full and Light users at launch

perhaps be seen as a local adaptation (Star & Ruhleder 1996) or improvisational appropriation (Dix 2007) that allows users to draw on a nexus of different technologies to fulfill their aims.

Because of the large number of requests for changes coming in during these first few months, very early on after the launch of the project we began to consider a 'phase 2', which would more tightly define, prioritise and group together the changes that were being requested by the consortium partners, thereby going some way to accommodating their need to 'have a say' in a timescale that was realistic for them. In this, once again we see that design continues into use, and moreover, as Robertson and Wagner observe, should be continued into use maintaining the foundational principles of PD (Robertson & Wagner 2012)

I think the idea is that you would use Hublink to refer but actually the reality is that you need to still pick up the phone and have a conversation, and then use Hublink as a way of getting information to them, rather than relying on it...and thats fine; its not a negative thing, actually you need that contact really. **Karen Linnane 13 March 2014**

Textbox 33: Use for referral

5.4.5 Struggling with Data Out

Over and above these relatively minor changes, for myself as lead developer and the consortium co-ordinator, the first phase of 'live' use of Hublink was dominated by issues related to reporting for the commissioner, London Borough of Tower Hamlets. Although being able to provide granular reports was a main motivator behind Hublink, the main part of the the actual reporting specification had not arrived from the commissioner until the very end of December 2013, with the equalities reporting categories not arriving until the beginning of February – well after launch. Therefore, in addition to the need to add fields for specific data and make existing fields compulsory, it was at this relatively late stage that we embarked in earnest on providing data outputs for the consortium.

The need to do this work was not a surprise to the development team and since the beginning of the project we had reassured the staff at *Real* that so long as the data was collected in granular form it would always be possible to extract it. While this held true in the sense that the correct information was being collected and held in Hublink, we underestimated the difficulties in extracting the data in the exact format required by the commissioner in a user-friendly way. Textbox and 35 and 34 shows that staff were aware that the granularity of the data was sufficient and potentially useful. Both myself and the project co-ordinator at *Real* were also unprepared for the extent that this quantitative data requirement can be open to interpretation. For example: In practice, many clients worked with consortium organisations on more than one issue, and so had more than one 'project' or 'enquiry' logged. So when the commissioner asks for a breakdown of cases by domain of service *per client,* we found that it was open to interpretation whether a client with two different projects with two different domains should be counted once or twice. Dealing with this issue was made more complex by the fact that the partners were still struggling to incorporate Hublink into their own workflows, and therefore and data was not always being entered consistently or on time.

It was also here that we came up against the limitations of the web-based configurability of the Drupal system. Drupal has a powerful and query-building tool called 'views' which has the capability to create good user interfaces for selecting and filtering data. However, the complexity of the data and the need for more than one level of aggregation was more than Views could manage. Bugs appeared in the community contributed modules as they were being pushed beyond their intended use and some custom code was needed to generate the correct data. Drupal could easily deal with the volume of data, but the complexity of the relationships between the data stretched its capabilities as a content-management framework.

What tends to happen in commercial databases is that people just start to miss stuff out; because that's not how I work so I just won't put it in, and what I found doing reports from databases is that you have a lot of information missing which I'm semi-confident that we won't have, because all the information we are asking people to collect is what we need and what we know they can collect, so I'm hopeful that our reports, though I think there is more work to be done on reports, I think that the information that we are going to get should be what we specifically need. **Cathie Duncan 13 March 2014**

Textbox 34: Reflection on reports

The benefit of hublink is that we can ask for exactly what we need to pull out of it. its all there. in other databases it would have been there but it would have been so intermingled that it would have been virtually impossible to extract it. **Cathie Duncan 13 March 2014**

Textbox 35: Reflection on use for reporting

There were various ways that the reporting issues could be approached so we discussed with *Real* how we might proceed. We discussed two options . One was that we could supply reports specific to each output required by the commissioner. The second option was to supply downloads of 'raw' data in spreadsheet form that could then by manipulated in a programme such as Excel of Open Office to provide the required information. The advantages of the second option as more transparency over the exact data that is in the system that would enable *Real* and partners to gain an overview of the data, so it would possible for them to check for gaps and omissions that might be attributable to the system either not working properly or data not being recorded. The raw data downloads would have the added advantage that same data should be able to be used for changed or additional reporting requirements, therefore giving *Real* more independence and control over the data. This suggestion could be seen as a way of drawing on the practices of tailorability, though in this case using tools that are outside of our own system. Indeed spreadsheets have been cited as good examples of end-user tailorable applications (Nardi 1993; Gantt & Nardi 1992) (Ko et al. 2011). The disadvantage of course is that the burden of work to write formulas for the spreadsheet would fall on *Real*.

It was obviously particularly hard in this situation with the consortium, where we had people in different organisations, and we needed to take some short cuts on the collaborative working. To have done that really properly would have been a massive project, but then not involving some people at that stage means that we are still...... yes catching up but it was, I'd still say, its significantly better than the traditional method of starting with someone trying to write a spec. **Mike Smith 9 April 2014**

Textbox 36: Reflection on difficulties with adoption

At this point, *Real* opted for the raw data option and so work focussed on making this as complete as possible. We worked on this up until the first set of reports were due in June 2014, and beyond. We also made downloadable reports available to each organisation manager.

To summarise this phase, there were many difficulties, especially the first three months. Adoption was difficult (Textbox 36) and the user interface did not suit everybody. Terminology used in Hublink did not always match the terminology used by case workers which led to confusion around the user interface.

The appearance of the application, that was more like a website or web survey than what people were used to as a database was a barrier for some of the partners though was popular with others. For reasons that we will return to, partners were not involved early in the process and that led to late-coming requirements and the problems were exacerbated by the late coming reporting templates. Nevertheless, the system itself was quite robust due to its basis in a well-tested Open Source framework. Added to that, the depth of knowledge that the staff at *Real* had gained from their involvement in the design process made it possible for the entire group to work as a team and tackle the issues that arose.

5.4.6 Reflections on phase 4

5.4.6.1 Having a say

A much discussed issue in the evaluation of Hublink has been the terminology used, especially the use of 'projects' which might – in other systems – have been called simply 'cases'. It is this departure from convention that was frequently mentioned in conversations difficulties in adopting Hublink. (Textbox 38). The origin of the decision to use 'projects' instead of cases can be found with Mike Smith, the CEO of *Real*, at the inception of the research. At the outset of this research Mike was keen to make the then speculative information system potentially applicable to all areas of *Real*'s work, not just its information, advice and advocacy casework through the Local Link consortium. The system should therefore match the overall ethos of the organisation. Therefore, if the use of the application was extended to other forms of involvement such as volunteering or campaigning - that had a stronger emphasis on mutual aid and empowerment – the language of 'client' and 'case' would not be appropriate as they imply an power relationship of dependency. It was also argued that even in advice and advocacy cases the language of 'projects' rather than 'cases' in Hublink implies greater equality and, though less intuitive for some professionals, could lead to positive shifts in perception.

There are some words that people don't use in their daily work, but there are some words that people do use, like notes and signposting and benefits and outcomes. So those are familiar but because they are mixed with words that are not familiar like projects people don't think they are the same. So they may say, where do I put my case notes, and I say, under that tab where it says 'notes' and they say; what does this mean, 'see all notes' I say, it shows you all the notes, they just think its another language, its Hublink language. **Ailidh Macloed 23 November 2015**

Textbox 38: Reflection on differences in terminology

We did at the time have an objective of trying to make sure that we didn't have never-ending advocacy and it wasn't just about how things currently work but how it should work… and I was very clear that I wanted a solution that would be adaptable to being a whole organisation tool. **Mike Smith 23 November 2015**

Textbox 37: Reflection on values embedded into terminology

Understood this way, it could be argued that while the practices and values of PD and the self-help ethos of *Real* were usually complementary, in the case of this decision on language and terminology, there was a conflict between the voices of the frontline workers in the design process and and the broader values of empowerment that underpin *Real*.

There was another area of contradiction revealed in this project between the bottom-up values of PD and the community sector and some necessities of the project that led to top-down decisions. It could be argued that the reports generation in this project, and indeed the whole driving task of gathering granular data, was implemented in a top-down way as it was primarily governed by the demands of the commissioner. With a finite amount of time and effort available on all sides, these inevitably took priority over facilitating data inputs and outputs that would benefit *Real* and its constituency. Michael Gurstein's discussion of the differences between CI and corporate Management Information Systems (MIS) sheds some light here. For Gurstein, MIS are geared towards efficiency, control and the production of data to enable top-down managerial processes and is in conflict with community values such as inclusiveness, transparency and equal access and of course benefit the community (Gurstein 1997). However, in the case of Hublink, the operating conditions of the organisation requires it to impose the goals of MIS on its operations, and as a professionalised, hierarchical organisation it is necessary for 'top down' goals to determine its systems. Therefore Hublink has many characteristics of an MIS, according to the definition by Gurstein, in its emphasis on meeting the needs of management and the use of its output for various quantitative managerial tasks, while also having many characteristics of CI.

5.4.6.2 Mutual learning

Continuing on from the gains observed during the previous phase, in this first phase of use we see the mutual learning from the design phase became an even greater enabler of Hublink's use in context. The absolutely crucial adoption tasks, including training partners, and acting as first-line for support questions continued to be substantial and continued to be taken on wholly by the consortium coordinator with the participation of other staff at *Real*. As evidenced through the reflective interviews, these staff members had a deep understanding of the application, and were highly confident and mostly self-sufficient in these adoption tasks (Textbox 39). Evidence for this is the very small number of support questions that were passed onto the development team (see section 6 of the case study).

Notably support queries increased later in the lifecycle of the project (see section 6 of the case study), when Cathie Duncan, the Project Co-ordinator and Operations Director Edward Pickering, who had both been involved in the design left the organisation. This underlines the importance of the learning gains from the design phase, but also their fragility .

5.4.6.3 Appropriation and Tailorability

As discussed in the literature review, appropriation is distinct from tailorability. Appropriation can be understood as the ability to find ways to meet ones needs within the constraints imposed by the system even when the system design does not cater to those needs(Dourish & Dix 2007) . On the other hand tailorability is the ability to change the system to better meet ones own needs (Pipek & Wulf 2009). In the reflective interviews, both appropriation and tailorability were raised as important methods that individuals used to make sure the system was usable in context. In both cases, participation in the design process was identified as the route to the

I think it is useful being involved in designing it yourself. I think you'd be more inclined to change your work process to fit with a ready-made system, which is not a good thing. I don't think the system should dictate your work. the client journey should dictate your work, and that's where we started with, what's the client journey? **Karen Linnane 13 mar 2014**

Textbox 40: Reflection on appropriation and work practice

We've been able to deliver Hublink to the other partners, and we've been able to train them up on it and give them information on it and get them on board with using it, because we've been involved in designing this and we understand it. if this was something that was just given to us i don't think we'd be able to impart our learning and training and understanding in the way that we have. **Karen Linnane 13 March 2014**

Textbox 39: Reflection on learning through PD

knowledge to take on these activities (Textbox 39, Textbox 40, Textbox 41). Providing even more evidence for the benefits of these gains, the journey towards end user development that started during the transition phase described in the phase 2 section of this study accelerated during this period.   The desire and ability of the leading users to make changes to the user interface and the data fields increased.   During this period, several support requests from the consortium coordinator during this period were requests to document how to make changes such on an ongoing basis rather than simply requests for changes to be done by the development team.   This can be seen as journey for participants where input into design led to the desire for more customisation, and finally to the desire to customise oneself (Textbox 42). This links to the ideas of meta-design (Fischer 2003), though is also distinct from it as our evidence shows that it is the desire and ability to customise comes primarily from participation during design, rather than through the design itself.

As in the transition phase, it was also observed that this high degree of involvement has negative sides; one that is personal and emotional, and another that is technical. The personal side is the pressure that comes with the sense of responsibility of having been a co-designer. This is expressed by the leading user when she feels the pressure to improve things she notices could be better. It is therefore observed that the knowledge and understanding that comes from participation has heightened a sense of responsibility and this is not comfortable (Textbox 43) . In contrast, she expresses that it might be easier to blame design flaws on a system in which she has no personal investment (Textbox 27).   This is a very important and unforeseen issue, and not explored in the literature to date; this point is further discussed in the conclusion of this thesis. More widely discussed are the issues of end user tailorable solutions being fragile and having the potential to lead to inconsistent data or functionality (Lieberman et al. 2006) . We found this was true but to a small extent. For example, we found that in making a previously

It just doesn't make sense to me to have to ask you to do those things every time because its a database that I'm using every day, I'm getting the feedback from people day to day. It just makes sense.   I have that understanding: I train other people to use it, how can i do that if I don't have that level of understanding? So actually i don't think it could have been any other way to make it a success. **Cathie Duncan 13 March 2014**

Textbox 42: Reflection on learning and taking on tailorability tasks

For me, it meant that we can flex how we want it, so we don't hopefully we don't get caught by that thing of doing what the database tells us what to do because we have designed it so its for us to play around with it or bend the rules about it, maybe if it had been a system that was introduced we might feel that we have to stick to it because we don't know quite how to work around it.   **Karen Linnane 13 March 2014**

Textbox 41: Reflection on appropriation informed by PD

non-compulsory field compulsory, an error was thrown when older data, from before the change, was saved.   It could also be said that some of our struggles with producing the reports was in some ways a negative result of the ease of tailorability.   Because it was easy to add new fields and gather new data, each time this was done the reports needed to be tested and adjusted. This made the work on reports more long running that it might have done and potentially more complex. Clearly there is a balance to be made between maintaining the usefulness and relevance of the application by allowing it to be tailorable, versus the risks of errors and instability due to change.

5.4.6.4 Infrastructuring

As the main part of the project in which design and use converge, in this phase the concept of infrastructuring begins to become increasingly relevant as a way of describing and analysing the project. The nine dimensions of infrastructure (Star & Ruhleder 1996), begin to become visible characteristics as Hublink becomes part of everyday work for the consortium: during this phase, Hublink becomes 'embedded' in everyday practices. Learning and adoption takes place both formally and informally by being part of the consortium. The application is used in different ways across the different partners, with adaptations locally needed whether that is to adapt to different technical infrastructures (eg. coping with slow internet connections at one site, or a thin client system at another). Nevertheless, standards need to be imposed in order to make thesystem workable and effective across the different organisations; there is an ongoing tension between the need to both 'link to conventions of practice' locally, while also adhere to standards that mean that the system can meet its original aim of creating consistency of record keeping and reporting across the consortium. Finally, we see the system, over time, becoming increasingly invisible, as indicated by the drop in support queries. However when there are breakdowns – which are few and far between – the absence of the system is noticed.

[working on Hublink] doesn't sidetrack me; I see it as part of my job, though perhaps not a part i expected to have… I wouldn't say that I've necessarily enjoyed all aspects of it. Its been quite a headache for me in truth but I think that's because its something I've never done before and I'm not used to having to think about it. I'm used to sitting and using a database that just works and I have to learn where I have to put different pieces of information. I'm not used to having to look at it and say well how do we make it ask for that information, why are we asking it to do and what are we asking it to do next. Having to take it that step further has been quite a steep learning curve, but now we are at the other end of it, a good learning curve. **Cathie Duncan 13 March 2014**

Textbox 43: Reflection on learning and responsibility

For the entire team, the transition from enjoying a research-driven design project into sustaining a long term infrastructure was a substantial challenge. The basis for long-term support had been planned into the project, through the ongoing support through the hosting provider Bytemark under a contract directly with *Real*, through the use of the Open Source framework, and through the ongoing support offer from Fossbox. Nevertheless the full weight of this ongoing responsibility had been underestimated (Textbox 43). Merkel et. al. Are one of the few research teams that have touched on the difficulties of sustaining IT infrastructures into the long term in a community setting (Merkel et al. 2005) . Phase 5 of this case study explores these pressures further.

It also should be mentioned that during this phase (April 2014) a series of interviews took place that provided a space for reflective exchange of views on Hublink's development. These interviews were intended to capture reflections on the process in order to evaluate the intangible outcomes of the project, and were not primarily intended to guide further technical or design work. However, they did provide an opportunity to air some of the tensions in the project as well as analyse its achievements. While it is impossible to evaluate whether the opportunity to air these issues had any effect on the unfolding of the practical aspects of the project, they did provide a space bring personal and even emotional dimensions to be aired and discussed. The reflective interviews surfaced the strong personal relationships that had grown up between the team and to the tool we were building together. Some of the emotions were negative, such as the anxiety felt at the added responsibility, though many were positive for instance the sense of ownership and achievement that comes with the ability to tailor a tool to ones own needs.   The concept of infrastructuring seems like a useful tool for analysis here, as it is able to encompass such intangible connections and recognise that they also have an underpinning role.

It does feel like something that we developed, we designed... yes it definitely feels like something that is unique to what we wanted and now its there. **Karen Linnane 13 March 2014**

Textbox 44: Showing co-creation

Having worked on a big dynamics project that went horribly wrong its good to see that this one didn't (laughs) … I've seen what a lot of other not for profit organisations spend their money on and it does worry me slightly that they spend a lot of money when something like this can do the job. **Edward Pickering 9 April 2014**

Textbox 45: Achievements of the project

A final reflection on this phase is to note that many of the difficulties we encountered during this time could have been mitigated by the earlier involvement of the project partners. Certainly these issues of wider involvement the project shows up both the tension within PD as it attempts to both adhere to a set of well-defined ethics while also working pragamatically to produce results (Robertson & Wagner 2012). This lack of involvement by the partners was a frequent topic of conversation in the reflective and evaluative interviews. Each time it was discussed the conclusion seemed to be the same: that broader participation would have been desirable and would have helped the project, but it was just not practical because of the resource constraints and working practices of the organisations. The work of Taylor and Burt show how VSOs, being low in resources and focussed on frontline work, find it difficult to participate in IT projects that plan for the future (2001). So although this lack in participation can be seen to undermine the ethics of PD as applied to this project, it also strengthens the argument for participation as it is so clear that participation is seen as a positive and useful strategy that benefits the goals of the project.

All in all, despite many challenges, Hublink did, during this period, become usable and work in ths phased has been essential in enabling it to fulfil its purpose of being an infrastructure for the local link consortium (Textbox 44 , 45, 46).

I would say its amazing what you've achieved in a limited time and resource, that you've had, and that we had available to give to work with you. so on that level, the overall endeavour has been very successful… yes we've got to work with staff and there are teething problems getting everyone to use it and use it well and stuff … but if we hadn't had this we'd have been stuffed, in terms of our ability to bid for it, and effectively spend the money and make it work. Without it, the bid would have been much less successful in actually getting it or making it work from day one; so if there is a genuine cost to this, others will need to know what that is. **Mike Smith 9 April 2014**

Textbox 46: Achievements of the project

5.5 Phase 5: The long haul

5.5.1 Timeline

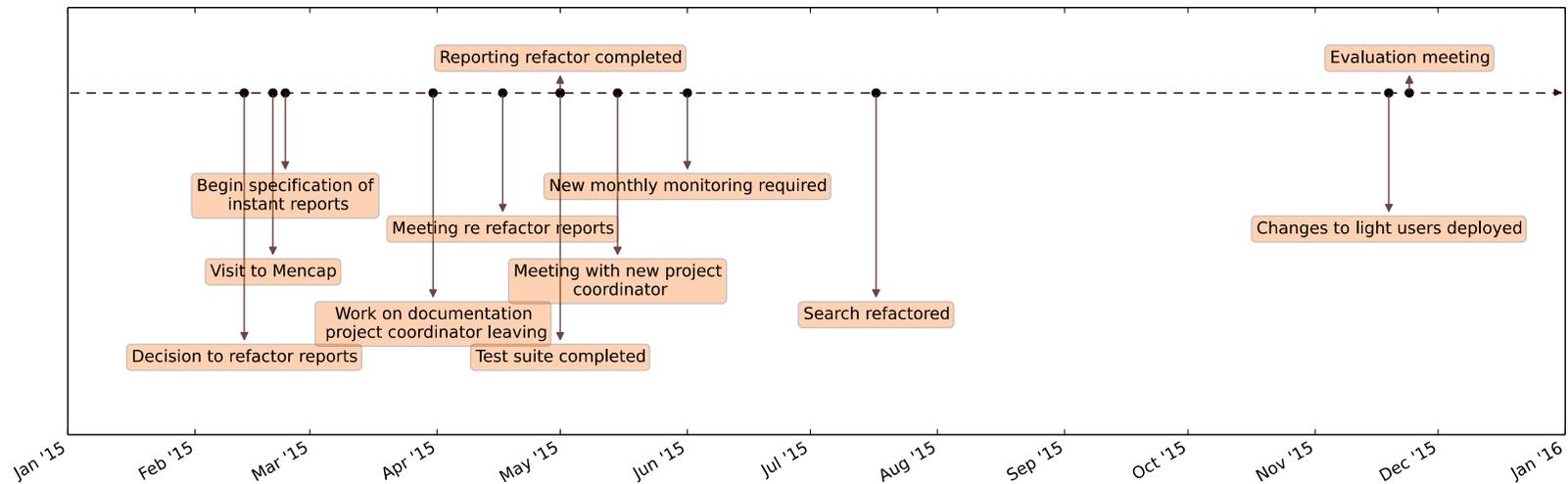*Figure 40: Timeline, phase 5*

5.5.2 Overview

It was only after November 2014, nearly 11 months into the launch of the project that Hublink
settled into a stable state. The overall work slowed, and the greater proportion was spent on
maintenance rather than changes and new features.   Work settled into a pattern that one could
foresee might be that for the rest of the project's lifetime.

That work is in two different areas. The first area of work is ongoing maintenance. The second is the continuing need to react to changes in the external environment.   These extenal changes were either within the organisation - for instance, staff changes - or outside of it, for instance new demands from the commissioning body. These external changes were particularly significant. The different kinds of changes all offered considerable challenges and required resilience from the development team, the team at *Real* and the application itself. These inevitable but unforeseeable changes run side by side with ongoing maintenance tasks that can be planned for.

5.5.3 Maintenance

An ongoing but important task through the long haul is applying updates and patches that keep the application secure and continually improve its performance. Updates and security patches are provided by the Drupal community to both core and contributed modules as and when needed. The modular structure of Drupal, adherence to coding standards and the community's procedures for checking and testing changes mean that an update will rarely, and in our case never so far, cause the application to break (Drupal.org 2015), and before upgrades are done, it is possible for developers to check the online bug trackers to identify any possible issues and pre-empt problems. In these ways, a project like Hublink which is small, but which is nevertheless crucial for its users, has the support of a much greater resource base than it could possibly do on its own. In other words, this maintenance stage is in large part serviced by the community, generativity and extensibility that are features of FLOSS software (Hill 2011; Zittrain 2008) This theme is take up further in section 6 of this case study.

Infrastructuring highlights the dependence of a system on a network of people as well as technologies. It therefore highlights risks as well as opportunities. One risk is over-dependence on one node in this network that might disappear. In this case, a major risk is the possible absence, for any reason, of myself, as the researcher who has invested the most time into the technical side of the project and the individual with the most knowledge about the project. Another risk is the loss of knowledge about the application that may make it unmaintainable.

From a practical perspective the generativity inherent in FLOSS can be seen as a way of addressing a number of these risks. Because of both the standardised ways of working and the large developer community, it is possible for any Drupal developer to understand and maintain a Drupal system that they did not build with a relatively small amount of documentation. This transferability of maintenance and the availability of developers through the Open Source community is one of the most powerful reasons to use Drupal at any scale (Parks 2013). Added to this, the costs are more predictable as they are not subject to arbitrary variations by a licensor (Lane 2015, pers. com, 20 October2015) . Figure 41 shows the nexus of connections that support Hublink.   With Hublink settling into a more stable phase, some of the tasks undertaken at the beginning of this phase were intended to address these risks and take best advantage of the features of FLOSS that benefit sustainability. These tasks were:

1. Creating a stable 'test suite' of automated, functional tests that could be run before updates

and changes.[1] These were done using the FLOSS tool Selenium.

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1   Tests had been documented and run through on changes, but they had been carried out manually. When applications change a lot it is difficult to keep a suite of automated tests up to date (Lane 2015, pers. com, 20 October 2015), therefore automated tests had not been achievable until now.

2. Standardising and documenting the ways the code repository and deployment were done with other projects maintained by Fossbox.

3. A security and hosting review with the hosting company.

5.5.4 New circumstances and demands

Maintenance is crucial, though it is predictable and can be planned for.   In contrast, most striking in this phase, has been the continuing need to adapt to change because of factors totally external to Hublink itself.

One example is the implementation in 2015 of the 'Care Act'. This piece of legislation gave local authorities additional responsibilities, and people who receive care from local authorities or are carers got new rights including rights of appeal and the right to financial advice, with advocacy if necessary [2] To fulfil some of their responsibilities under the care act, London Borough of Tower Hamlets contracted the IAA consortium to fulfill some of these responsibilities, as an addition to the work already done under the Local Link IAA contract. This led to new and essential changes so that Hublink could gather data and report on this new field of work, which is all the more important because it is a legal requirement. Once again, the configurability of Drupal and the flexibility built into the design of the custom functions such as allocating projects to groups meant that these changes were not difficult to implement.   Figure 42 shows some of the new fields added.
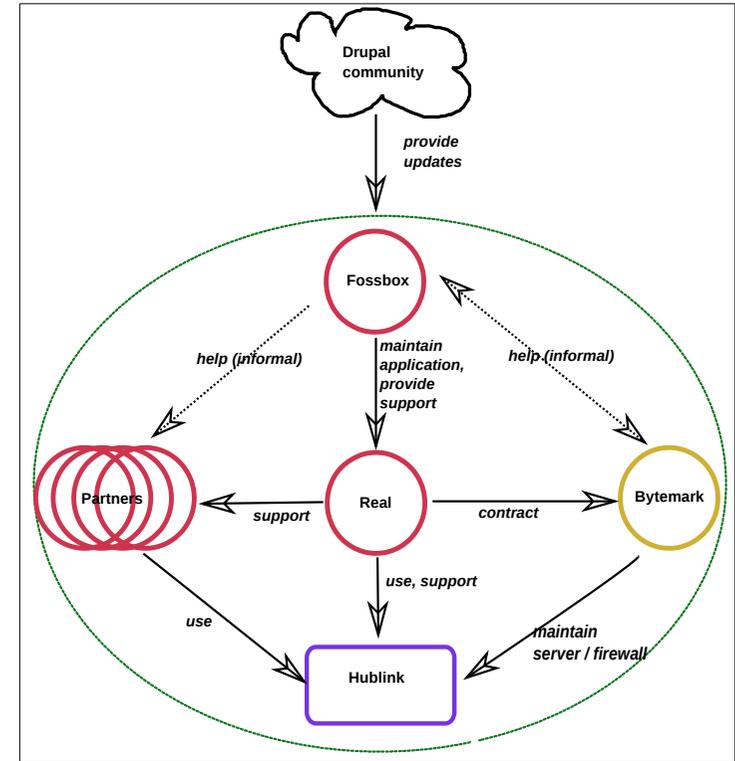

Figure 41: Hublink infrastructure

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2   http://www.theguardian.com/social-care-network/2014/jun/05/care-act-most-important-amendments.

170

Another source of change was at the local government level where there were more changes in the reporting requirements from the consortium commissioner, The London Borough of Tower Hamlets. In February 2015 and again in October 2015, new versions of the reporting templates were issued with new specifications for reports. In the case of the October templates these were significantly different from the ones that had been used during 2014 and the beginning of 2015 for which *Real* had set up re-usable spreadsheet formulas.   The necessity to re-address reporting was reinforced by the conclusion we had reached, as a team, that the reporting was not working well enough and it was necessary to backtrack from reliance on the raw data downloads.   The project co-ordinator was simply overwhelmed with size of the data output and the complexity of the task to create filters and formulas to reach the correct data outputs required by the commissioner, so even before new requirements for reporting were received a decision had been taken to make the reports more bespoke and simpler for the end user.

Figure 42: New care act fields

Therefore, in Spring 2015 a substantial piece of development work was taken on to recreate the reports in a new, easy to use format. This was a large piece of work but was completed successfully and was also able to be revised reasonably efficiently again when the requirements from the local authority changed yet again in October 2015 and when the Care Act was implemented. Figures 43 and 44 show the result of this work.

A frequent issue that had arisen during our evaluations was that the effort towards producing reports was overwhelmingly focussed on satisfying the reporting requirements of the commissioner rather than creating access to data that would be useful and insightful for *Real* and the consortium in developing their services and finding out about their clients. Therefore, during this phase the faceted search was re-factored to make a clearer and more flexible way to

browse the data. The re-factored design also added features to make the faceted search more sophisticated in its ability to cross-reference between attributes of a client, such as their impairment, and attributes of a project, such as its primary domain (housing, health, benefits etc). (Figure 45)

Figure 43: Filters on new style 'instant' reports allowing different date ranges and different criteria to be chosen by the user.

Even closer to home, at our partner organisation *Real* there were staff changes. First of all the Operations Director left in November 2014, and then the Consortium project co-ordinator left in March 2015. As described in the previous section, the project co-ordinator had beyond doubt been the most crucial member of staff in developing and implementing Hublink and had been the most active and instrumental in taking over the adoption and end user development tasks. The Operations Director had main oversight of the hosting, security and data protection aspects of Hubink and these responsibilities had to be handed to others in the staff team and supported by the development team. The loss of these staff members were a significant challenge.

Information, Advice, Advocacy and Care Act Advocacy

Row	Benefits	Employment	Financial advice	Health	Housing	Leisure	Other	Social care	Travel	Volunteering	Total
Age UK East London	349	6	63	12	67	12	77	26	12	0	624
Alzheimers	0	1	1	1	1	0	0	30	0	0	34
APASENTH	838	9	223	10	98	2	56	28	104	0	1368
BbBC	47	0	3	0	9	0	2	0	0	0	61
deafPLUS	81	10	68	89	107	41	51	14	36	0	497
Mencap	4	2	2	4	12	4	19	36	0	7	90
Positive East	98	25	34	19	34	0	14	0	3	8	235
Real	144	7	12	9	49	13	24	37	9	2	306
THLC	122	8	2	4	101	0	1	0	0	0	238
Total	1683	68	408	148	478	72	244	171	164	17	3453

Figure 44: Result of 'instant' report, showing domains of service broken down by organisation. Test data shown.

5.5.5 Reflections on phase 5

5.5.5.1 Infrastructure and infrastructuring

In this phase the settling down of the system into what is recognisable as an 'infrastructure' in the terms discussed in the literature review (Star & Ruhleder 1996; Karasti & Syrjänen 2004; Pipek, V. Wulf 2009; Karasti et al. 2010) is observed. The application was embedded into its context, and as part of everyday work, had become fairly invisible. Changes required by the wider user group had been negotiated with the original design of the system as a whole. New staff members were able to learn about the system from existing users and the available documentation. Breakdowns were few and far between. Though occasionally, when organisations could not get access to the application because of a configuration change in their own local environment that did not pass security requirements, Hublink became a focus of concern.

In this phase it is also possible to see the fragility of this infrastructuring network, which is made all the more vulnerable by the relatively low level of resources that VSO's work within. This thesis provides evidence and argues in favour of PD having the ability to build knowledge and capacity in participating organisations. This instability caused by staff leaving both provides further evidence for this but also highlights its limitations and the need for adjustments in the PD process to better embed these learning gains in organisations. Is is however worth noting that staff leaving left gaps of knowledge and understanding, not just for Hublink but for the consortium service as a whole (Textbox 47 and 49).

Figure 45: Filtered search documentation see appendix 2 for larger version.

This fragility is expressed within the infrastructuring perspective tells us that infrastructure is not simply a matter of technical artefacts, however interconnected they may be, and accepts that sustainability of systems is an ongoing process that also involves the relationships between people and between people and artefacts (Karasti 2014). This interdependence of technical artefacts, individuals and communities is observed also observed looking beyond the Hublink team, and is especially evident when looking at maintenance. Hublink is dependent for maintenance and security on open source communities which have their own internal dynamics. Bridging between Hublink and its context of use is Fossbox which brings together developers who share a set of values and Bytemark, a commercial company but which also supports Open Source projects. Figure 41 is a key artefact in this research, illustrating the network of support that enables Hublink to function as an information infrastructure in this context.

5.5.5.2 Tailorability and Infrastructuring

Simonsen and Hertzum (2008, 2012), Wolf and Pipek (2009) and Giaccardi and Fisher (2004) have all argued that the ability to continuously customise, or tailor, and application is key to its ability to remain fit for purpose over the long term.   The changes that took place during this phase, one year or more after the production phase, are a clear illustration of these observations. Tailorability is linked to infrastructuring as a need to respond to changes in the environment to enable long term relevance, but also to both address and reinforce the desire to reshape technologies that comes from a sense of ownership over them (Pipek, V. Wulf 2009; Carroll & Rosson 2007) . Textbox 48 , an email from a frontline worker at *Real* who who has not yet joined the organisation during the design of Hublink, shows how at least some users still had a sense that they could have input into the design.

It's still an ongoing piece of work in terms of the consortium working together, having added value. Lots of personnel in the organisations have changed, going into the third year now, including our own organisation, and that has had an impact. And it has felt at times like starting again with some organisations, and resetting expectations and understandings, as staff models changed.   There's definitely a sense of coordination and working together but alongside that there's been some hiccups along the way; quite often its when staff changes. **Karen Linnane 24 November 2015**

Textbox 47: Reflection on responding to change

The tailorable architecture of Drupal came into its own once again with the Care Act changes. These could be implemented almost entirely through configuration. Therefore they were not too onerous and carried little risk of creating instability of previously stable functionality. It was not too difficult to add in some new fields and create new outputs; the work was quick to implement and required one face to face discussion and a look at some paperwork to establish the requirements. The automated tests also helped such changes to be undertaken relatively quickly with confidence that the rest of the system would still work as expected. This crucial tailorability is not a feature exclusive to FLOSS systems. However, as will be discussed more in the conclusion of the thesis, the affordances of tailorability in FLOSS systems is driven and supported by common community need and, through the structure of Open Source licenses and technical practices as described in the literature review, is unfettered in its reach and scope.

The reporting side was more difficult, though the barriers were surmountable with hard work and patience on all sides. When the project co-ordinator left *Real*, the task to create an easier and more accessible way to create reports became more urgent as it was clear that the work in manipulating the raw data downloads was not going to be replicable by a new staff member. For the new piece of work, a different approach to the original raw data downloads was taken. In this approach, the data was extracted by direct queries to the underlying MYSQL database, and Drupal used to format the output and provide a user interface for filters (Figures 43 and 44). The approach is opposite to the raw data downloads because it replaces transparency and the ability to manipulate the data in external spreadsheet applications with uncontextualised figures that are easy to obtain but cannot be examined or further analysed by the users. Pragmatically, this new approach suited *Real* well and helped them meet their obligations. On the other hand, the transparency and ability to double-check the data and the knowledge the emphasis on the community partners being in control by being able to independently manipulate

Hi Lisa,

Me again! I have an idea for a function within Hublink.

We receive referrals via email that have a referral form attached in .pdf or .doc format. At the moment, the form can only be uploaded to a project once a worker has been allocated and he/she uploads it within a Note.

It would be useful if there were a function to upload relevant documents to a project at the point it is created.

Is this something possible to change?

Regards

Textbox 48: Email from one of the Real Advocates

the data to get new kinds of results was a deficit in many ways. Nevertheless, the decision to implement simpler reports soon proved itself once again when the commissioner requested monthly instead of quarterly reporting in June 2015, more than a year and a half into the contract.

Some of the challenges in this part of the project can be related to the high level of tailorability. Lieberman et al (2006) have noted that frequent changes by users can lead to inconsistencies and errors. This problem has occurred with Hublink but not to a great extent. In summary, while tailorability has been essential in both being in control and staying relevant to the task at hand, the difficulties faced with reporting show that this comes with a penalty. These problems are embedded in the underlying structure of the Drupal system which, in order to provide it high level of end user customisation, has a very complicated underlying database structure. This structure is much more complicated than it would be if the database had been designed for a single and fixed purpose. In the Hublink project the difficulty in generating the reports is a direct consequence of this, and the flexibility of the outputs has not matched the flexibility of the inputs.   As Star & Ruhleder predicted with their groundbreaking study in 1996, the difficulties in creating systems that are both configurable in different situations while still being usable and robust are significant (Star & Ruhleder 1996).

On the positive side, though onerous, the raw data output can be seen as a kind of prototype for these more 'instant' reports. They gave myself as developer and the Project Co-ordinator the opportunity to iron out a lot of the ambivalences in the reporting requirements from the commissioner as well as providing a way to check the consistency of the data in Hublink early in its implementation.   In the longer term, it should be noted that *Real* continued to use these

reports to get a more transparent and flexible view of their workload for their own research while finding the instant reports useful for the reporting requirement.

5.5.5.3 Mutual learning

As discussed in the previous section, the loss of key staff members created major issues (Textbox 49). It was impossible for the new member of staff to replicate the knowledge of the previous project co-ordinator that had been gained through the design process and the intense collaborative work in the transition phase. This shows that mutual learning through involvement in design is both a great benefit to sustainability, but unfortunately creates a risk if that learning is too concentrated within one or a few people. It was also noticeable that the trajectory towards end user development stalled when she left.

On the other positive side, when staff left it was found that there was a good level of knowledge and understanding of Hublink among other senior staff who had participated in the design, even though they did not use Hublink often.   Thus, through the involvement of senior staff in the design process the learning was distributed among several staff members, and the understanding of Hublink was still embedded in the organisation. This helped staff members to support the transition between staff members. This transition was also helped by the fact that the outgoing project coordinator had used her knowledge to produce a large mount of user documentation in the last months of her work at *Real*. Nevertheless it was notable how much knowledge was lost and this is reflected in the larger number of support queries that occurred after she left.   Despite

We knew it would be complicated to bring 9 established, well known organisations together, the most difficult thing was getting people to recognise that this was something different, but I don't think that was a surprise that that would be difficult… I'd probably not clocked about staff changes and the lack of transfer of ownership and ideas within organisations. **Mike Smith 24 November 2015**

Textbox 49: Issues with continuity across different organisations

177

these losses all the partners continued to have a productive and negotiable relationship, and interestingly, even new staff members did on occasion approach me with ideas for relatively small customisations (Texbox 48). This indicates that there is still that strong sense of ownership that comes from having what users feel is a malleable platform. Overall, Hublink has continued to be a strong element in holding the consortium together; which is itself an ongoing and challenging task. (Textboxes 50, 51).

5.5.5.4 Control

The literature on community informatics tells us that control is a paramount concern when implementing systems by, with and for community organisations. Hublink in its 'long haul' state illustrates a number of positive and negative lessons related to control. Gurstein highlights the importance of forming partnerships that do not treat the client as a potential customer, and does not impose inappropriate or un-needed technologies Instead CI stands for the development of productive relationships with communities that engage their talents and interests in a way that does not involve technological determinism or colonialism by stealth (Gurstein 1997).

Firstly, as we have noted, the use of FLOSS and specifically a framework with a large developer base such as Drupal does give control to the community partner in theory. *Real* have so far been satisfied with continuing to work with Fossbox and so have not chosen to exercise its ability to change developer. This is positive, but the consequence is that the organisations' contact with FLOSS communities is mediated by the researcher and Fossbox. Therefore they have not always feel fully in control (Textbox 52). Secondly,

[evaluating the level of joined up working from a client's point of view'] I would say that if what the public got was probably 4 out of 10 previously, and our ambition was 9 out of 10, they probably get 7.5 or 8 out of 10. **Mike Smith 23 November 2015**

Textbox 50: Overall success

We have not reached our full potential as a consortium at all, but we are well on the path to it. **Karen Linnane 23 November 2015**

Textbox 51: Challenges still to come

178

from the outset, Fossbox was keen not to mediate the relationship with the hosting company, and therefore made sure that *Real* 'own' this relationship. *Real* has a contract with Bytemark direct, and have direct access to technical support. However, in practice since the departure of the key staff, this relationship tends to be mediated by Fossbox as *Real* has limited in-house capacity to manage this relationship and the questions that occasionally arise. This seems to back up Taylor and Burt's observation that VSOs with IT specialists in staff adopt and sustain technologies more easily (Burt & Taylor 2001).

From these points one might conclude that it is only via infrastructuring, ie. via wider network of relationships that have personal qualities such as trust in addition to contractual underpinnings, that enable the long term support and mitigation of risks in a small scale project in a community context such as Hublink.

...there was never really any understanding of what this meant for us at as an organisation at an early enough stage… around hosting and what that meant and so in terms of building a whole solution rather than just a database, some understanding of that earlier could have helped **Mike Smith 9 April 2014**

Textbox 52: Reflection on control

5.5.5.5 The project's end?

In the review section of this thesis the different ways of thinking about a projects' 'end' were surveyed. A number of models were suggested. Iversen and Dindler suggest that scaling and replication, meaning the wider adoption of a system, is a way of ensuring the sustainability of a PD project (Iversen & Dindler 2014). Ehn et al take a different view, suggesting that projects should be seen as unconstrained and instead should be formulated as inherently sustainable via infrastructuring activities (Ehn 2008). This project shows that in practice, there is no end until the system is retired and the data migrated. Nevertheless, on reflection, Iversen and Dindler are making a relevant point when they suggest that scaling and replication can have a role in sustainability. As an Open Source project, Hublink could be replicated and used for other

organisations or consortia, and through that, an economic basis for its ongoing maintenance and development could be assembled (Textbox 53). The way forward suggested in Textbox 53 reflects a FLOSS business model in which companies do not sell software, but specialise in deploying, customising and maintaining a specialised package across several clients. Since Hublink's launch, replication along these lines have been discussed many times as a possible way to secure its future and thereby increase support for *Real*. However, Fossbox lacked the resources to develop Hublink as a generic package in this way and this is not a core concern for *Real* as an organisation. While this exact kind of replication is probably not what Iversen and Dindler had in mind, the focus on replication and scaling is an interesting insight in the FLOSS context and highlights a potential route to sustainability that harnesses the mutual learning outcomes of PD.

There is some kind of like Platform as a Service model that Hublink could materialise into, but it does need some impetus. Clearly Paula cant put loads of money into something no-one is going to adopt but it kind of needs someone like the CVS to go 'right folks, this is available and its relatively cheap, what do you think?' **Edward Pickering 9 April 2014**

Textbox 53: Scaling and replication

For Hublink therefore, with the lack of replication and with its ongoing use in a real-world context, this is a project without end for an extended timescale. The infrastructuring model provides us with some tools to address this challenge and approach sustainability by mapping out the projects' needs and putting in place the needed network of expertise. This planning is manifested for instance through the continued relationship with Fossbox that offers support to the application by applying security updates from the community and answering support requests. From the outset of the projectt, by brokering the relationship with Bytemark for hosting infrastructure and supporting technical learning wherever possible within *Real*, Fossbox's approach has been to enable *Real* to take as much control as possible and this is still the preferred approach. Flexibility and control over for the future of the project has been built-in by the use of FLOSS, so that *Real* can find other technical partners through the many individuals and small enterprises who specialise in Drupal. Also, in contrast to some propitiatory systems, they can extract and transfer their own data to other platforms.

Despite the challenges of supporting Hublink over the long haul in the face of its own resource constraints and the unstable nature of the Voluntary Sector as a whole, *Real* at time of writing (November 2016) are still using Hublink, are in an extension period for the Local Link consortium after its initial 3 year period, and are applying for another 3 year commission. There are still issues with adoption throughout the consortium, especially as each organisation has had its own cycle of changing staff, but on the positive side the application has so far been stable and remarkably adaptable, and is now firmly embedded as an infrastructure.

5.6 Data Analysis

5.6.1 Introduction

The previous five sections of this case study have provided a deep, qualitative description of the Hublink project. In this final section a contrasting approach is taken in which the data collected as part of the technical development process is re-purposed. In this sense, the work in this section is inspired by a Digital Humanities approach (Kirschenbaum 2012, Spiro 2012), which applies data analysis and visualisation to digital data that already exists for another purpose, and to see what insights may be gained about human-centred phenomena.

In the development of Hublink, a set of software development tools were used to organise and track work on the project. These FLOSS tools are widely across the industry used for organisational tasks such as distributing tasks among developers and tracking code changes, including allowing developers to work simultaneously on the same code base.   The tools are described in more detail in the next section.

The usage of these tools leads to an accumulation of quantitative data related to the project and provide a record of the actual work done by developers. Even though the primary purpose of these tools is technical and organisational, this data set is potentially useful for other purposes. It provides a consistent record across the lifetime of the project, regardless of the type or intensity of work that is going on in production, and independent from the reflective activities undertaken. In the spirit of case-study research, which advocates the application of many sources of evidence to the same subject, the investigation of this data is seen as an opportunity to triangulate the qualitative research via a contrasting method as advocated by, for instance Gillian R. Hayes (2011). In this section therefore, a challenge is undertaken to use this data in an innovative way, geared toward the human-centred and reflective underpinnings of the project. Through this data an attempt is made to verify or contradict reflective observations and, through data visualisation, provide a form of description that contrasts with that constructed through interviews or practitioner reflection.

Analysing this data cannot, on its own, answer the research questions of this thesis directly but it can address some its components. The first question states:

> *How does a PD design process, in a community context, benefit the sustainability of a*
> *project beyond the design phase, as it moves into the phases of adoption and ongoing*
> *use?*

This question involves a causal relationship – between PD and sustainability – that cannot be directly answered simply through this data. However, the literature review and case study have both identified maintainability and tailorability as key components of sustainability. The data analysed in this chapter reveals facts and patterns related to these areas. These patterns help us understand what kinds of activities have taken place at what stage in the project, and how important changes in the operating environment, for example staff leaving or new government

requirements, have impacted the project. The data therefore both provides an additional level of description and verification, and a planning resource for this and similar projects.

The second part of the research question states:

> *What specific benefits to long-term sustainability are brought about by using Free/Libre and Open Source software?*

This issue can be addressed directly by this data. Section 5.6.5 shows the extent and frequency to which improvements and security fixes coming directly from FLOSS communities are applied to Hublink through its lifetime. Through this data, the exploration of the theme of infrastructuring is deepened by showing the pattern of this contribution.

It is also important to note that, because the tools described below are standard across different software projects, spanning all scales of operation and operating contexts, this data has the potential to be a source of comparison between projects in further stages of research.

5.6.2 Introduction to development tools

The main tools that will be used in any but the very smallest software project are:

1. **Code repository:** Code repositories store and track changes to program files. These tools typically provide the capability to create and merge 'branches' . Branches allow teams of developers to do different tasks simultaneously on the same code base. Changes made to the code base are called 'commits'. A commit is made when a change is submitted by an individual developer and is typically accompanied by a 'log message' which describes the change. When the work of different developers is ready to be integrated into a new version, the branches are 'merged' and the repository software flags up any 'conflicts' where the same parts of a file have been worked on by two different people. In this way, the progress of the code base of a project is always traceable, changes can be associated to particular developers or tasks, and it is always possible to retrieve earlier versions.

2. Issue trackers: Issue trackers are systems in which issues are raised, documented and categorised in the form of 'tickets'. These tickets are often re-written to represent tasks, and those tasks, in the form of tickets, are then assigned to individual developers. Tickets typically go through a number of workflow states such as opened, assigned or closed, so that their status can be determined. Feedback from other developers or users may be input as 'comments' on a ticket. A task is finished when a ticket is closed.

In many development tools, code repositories and issue trackers can interrelate. For instance, in Github – a repository hosting service used by many FLOSS projects and developers - ticket numbers from issue trackers can be included in commit log messages so that code commits can easily be related back to more extensive documentation of specific issues.

These development tools have the primary purpose of organising work and code. However through the commit log messages and the content and categories of the issue tracking tickets, a lot of data is accumulated about the project. This data can be used for the management or analysis of software projects and software developers. Examples of such analysis widely used are geared towards project management, for instance tracking the productivity of individual developers, or monitoring the progress of a specific project to help management tasks such as time estimation. An example of a typical piece of data analysis used in software projects using the agile methodology [1] is the 'burndown chart' . In these charts, issue tickets closed and remaining open are analysed to produce a data visualisation of the work remaining in a project and the estimated time still needed to finish the project.

5.6.3 Use of development tools with Hublink

Hublink has been a relatively small software project involving just two developers to date, though in the future more developers could join the team. Moreover, in Hublink software project management methods such as 'agile' have not been used. Though there is some relationship between the adaptive, evolutionary approach of Agile development and the principles adopted for this project, the agile methodology is still too paperwork-heavy and resource intensive for this project. Instead the approach used for Hublink, as described extensively in the case-study, has been human-centred; based on collaboration, co-creation and negotiation with users who are partners in the development process.

Nevertheless developers must organise themselves, and code repositories were used in this project and, to some extent, issue tracking tools. The code repository Git [2] was used from the inception of the project and used to update all areas of the code base, including both custom elements and those that are contributed by the community. The platform Github was used to provide a central and repository in an online space that could be access and potentially controlled equally by ourselves or our partners[3] [4] , or could be transferred easily to other developers Real might want to work with. For issue tracking, we used the issue tickets system provided by Github. Although Github issue tracking is is not as fully featured as some other code management platforms, Github was adequate for our purposes as we were a very small team. After each of the iteration meetings the feedback was broken down and written up into tasks and entered into the ticketing system. See figure 46 for an example view of tickets from our project generated after the first working prototype meeting. A full listing of all tickets created is available on request.

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1 Agile is a project management methodology widely used in web development that emphasises self-organisation among development teams and short cycles of continuous improvement. See section on further work.
2 Git is a widely used FLOSS code repository software tool that tracks versions and changes and helps organise distributed work on software and other projects.
3 This is in contrast to other possible arrangement in which the repository could only be available on platforms hosted by Fossbox or the developers.
4 We later moved the platform to the provide Bitbucket as it has slightly better security features that suited our collective maintenance arrangements through Fossbox.
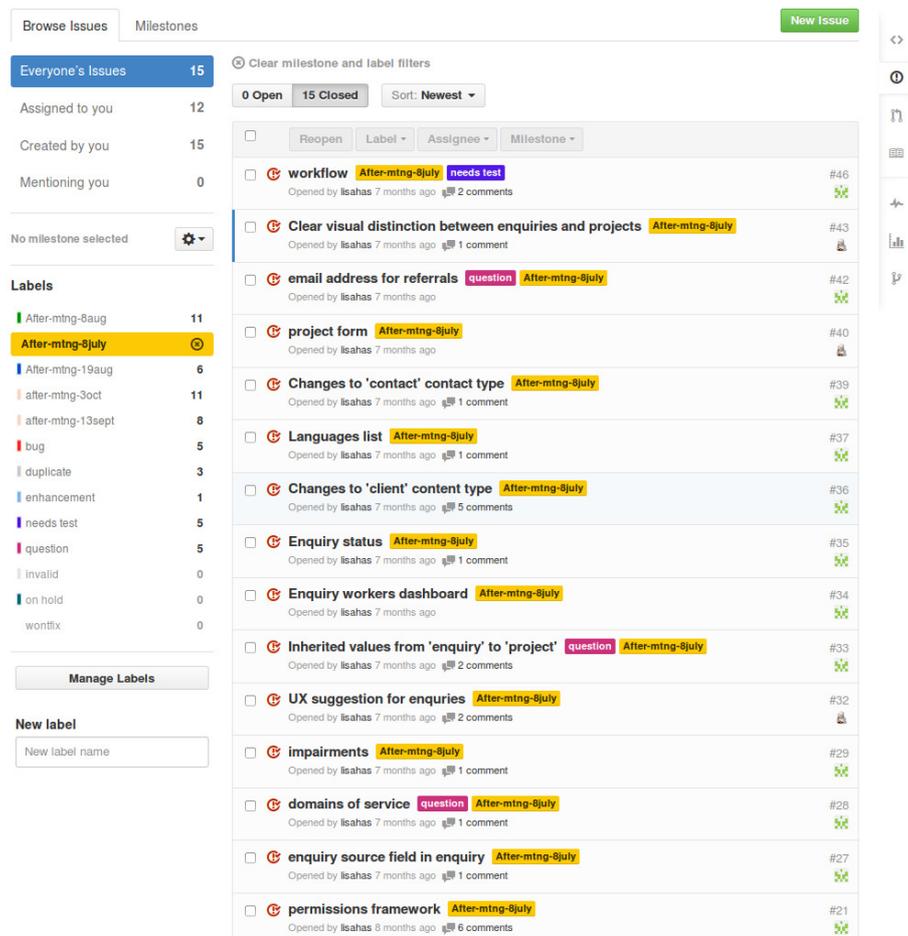
Figure 46: Screenshot from Github: list of tickets tagged with 'after-mtng- 8July'

In larger projects, project partners for instance clients or commissioners who have access to the issue tickets system and can raise issues there directly. However, for this project it was decided not to invite our community partners to use this system directly, though we did discuss this possibility with them. It was felt that having another system to learn to use may have been onerous and confusing, and might have detracted from the focus on Hublink. Instead we used emails and later a shared document kept on Hublink to raise issues and keep track of tasks. Therefore the issue tickets were under the control of Kate Lomax and myself, though we often rewrote or copy/pasted relevant emails we exchanged with Real staff into the ticketing system, especially during the transition and design in use phases of the project when we were responding to feedback of the system in use. The comments were also used as a way of recording how issues were solved and therefore provide ad-hoc technical documentation. We did not always create tickets however and so much information about tasks is also held in emails and other documents. Where relevant, I describe below how that information was integrated manually with outputs generated directly via the API's[5] of the issue tracker system to produce more comprehensive data for analysis.

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5   API's are 'application programmer interfaces' which allow programmers to access data or functionality in structured ways so as to create new applications or data analyses from external sources.

5.6.4 Data analysis

The charts in this section have been generated using custom code using the tools GNUplot, Python, Pandas, Juypter Notebook and Matplotlib, and using the data from code repository logs, issue trackers and emails. The raw data used can be found in accompanying material 3.

Three different data visualisations are offered in this section. The first – 5.6.5 Contributions of Open Source communities – addresses the second part of the research question which asks how FLOSS contributes to sustainability. This visualisation aims to shows how FLOSS supports a project in the long term with ongoing updates and improvements. In turn therefore, it shows how the long term support of an individual project like Hublink needs to plan to apply these fixes across the life of the project.

The second – 6.5.6 Changing design and development needs over the project - investigates the need for continuous customisation, which has also been identified as a key component of sustainability.   The patterns revealed here also can help plan infrastructural activities such as ongoing support and staff training.

The third – 6.6.7 Source of solution - sheds light on the core research question by showing how problems were solved. It shows how patterns of support changed over the lifetime of the project, revealing the impact of changes such as staff leaving or new requirements emerging through changes in the operating environment. By comparing how many changes needed to be made in code against problems that could be solved solely via configuration – and therefore accessible to be done by experts who are not developers - we can begin to evaluate the potential of leading user tailorability in this and future projects, and see where end-user tailorability might usefully be designed-in for the future.

5.6.5 Contributions of Open Source communities

The infrastructuring perspective suggests that the ongoing support of an information systems project relies upon a network of technical artefacts, individuals and tools in a constantly active and changing relationship.   Moreover, research community informatics tells us that the necessity to see ongoing support as social and as a process is amplified in the community context where resources are limited and common values and community control are important. This thesis argues that FLOSS artefacts, that are themselves dependent on their own communities, are essential component of infrastructuring in a community based information system.   To address this question in earlier parts of this case study I have described my everyday practice as a developer. However, this is also an area where data analysis from the code repository can triangulate these observations.
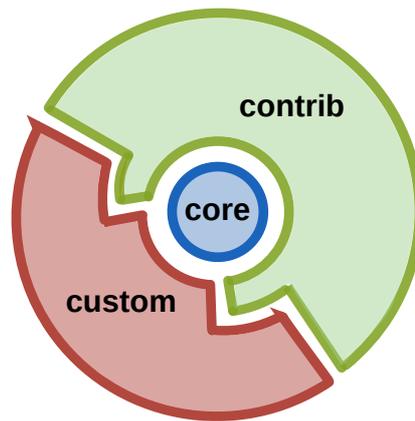
Figure 47: Drupal software structure

Figure 47 shows the structure of the code in Drupal that illustrates its extensible nature. Extensibility is discussed as a feature of FLOSS in section 4 of the literature review of this thesis. Figure 47 shows that core code forms a centre of basic functionality which can be altered or extended by 'contrib' code ie. modules contributed by the Drupal community. Custom code adds specific functionality relevant to this project only. Custom code may interact with core functionality directly, or with contributed modules. Interaction between these different levels happen via well structured 'hooks' (often called APIs in other contexts).
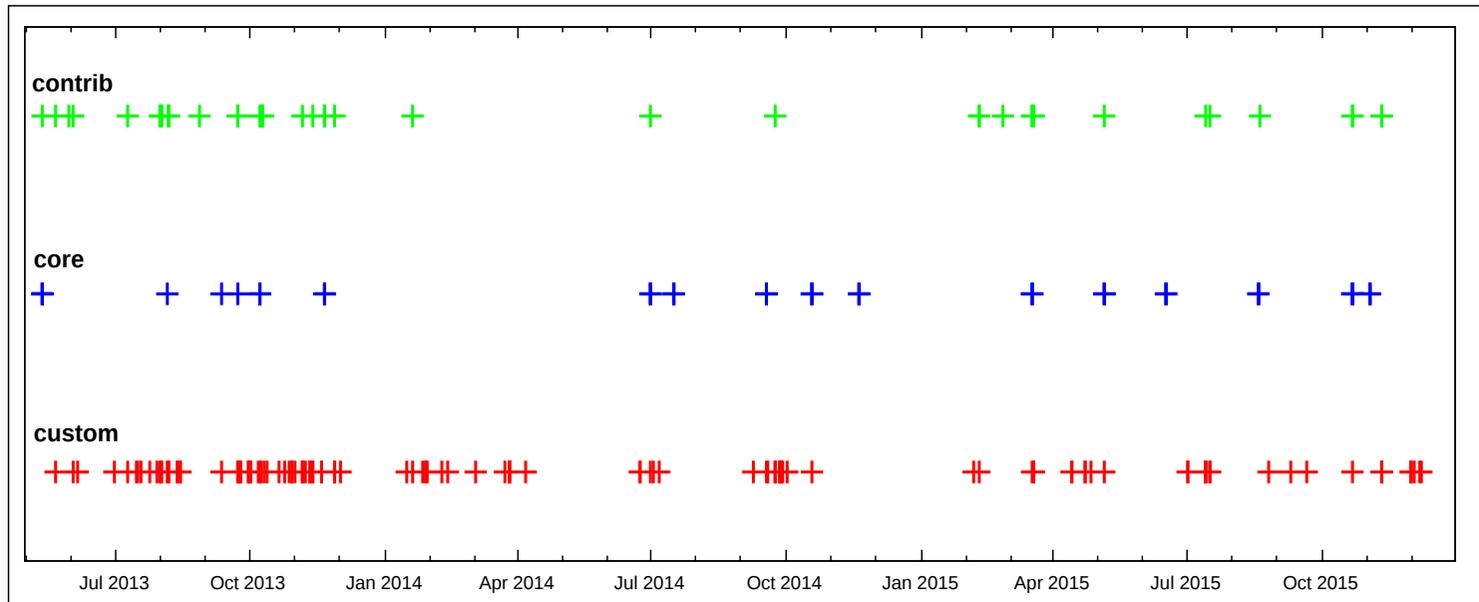
Figure 48: Commits to core, contributed and custom parts of the Hublink codebase

Figure 48 shows a timeline where each commit is shown with a cross. The crosses do not show the size of the commits, simply when they occurred. The commits are differentiated according to which parts of the code base that they alter. Blue crosses show commits to the core part of the code base, green to the contributed part and red to the custom part. This chart shows that custom code changes occur along a 'bursty' pattern that corresponds to phases in development. Commits are particularly concentrated during the development phase of the project when all the key features were being put in place, and then in the first few months of the project represented in the case study as the phase 3: design after design where many changes were still being made. After that there are bursts of activity that correspond to additional development phases as described in phase 4: Design-in-use, and section 5: The Long Haul of this case study. However, for core and contributed code the pattern is different. Following the initial installation of the system (April – Dec 2013), the updates are more evenly spaced. The commits correspond to the release of updates, including security updates. This pattern illustrates how the FLOSS community provides ongoing support even after the main effort of development is over.

188

The code changes to core and contributed code represent incremental improvements and essential security fixes, and are fully tested against core code and the most commonly used contributed modules before being released to the community. Therefore they provide high quality, reliable ongoing maintenance. While it does not cost any money to access the updates, but from the perspective of an organisation using the software, the maintenance is not entirely cost free. The fixed need to be evaluated and applied by a developer. But this is not generally a large piece of work and can be undertaken by any developer with Drupal knowledge. In the Hublink project, Fossbox provides ongoing, reliable support through its network of developers.

5.6.6 Changing design and development needs over the project lifetime

Issue tickets provide a history of a project. By categorising issue tickets and visualising the data it is possible to describe the shape of a development project over time. For Hublink, the ability to change and adapt the software has been been crucial to its ability to fulfil the requirements of the consortium over time. This is the exact issue raised by Wulf and Pipek (Pipek, V. Wulf 2009) in their discussion of tailorability as an essential part of infrastructuring. They point out that the ability of the technology to accommodate ongoing customisations, and the availability of skills to undertake tailoring is key to sustainability. In the case study this has been observed and recorded in case study section 4: Design after design and case study section 5: The long haul. Figure 49 shows how the kinds of development tasks required change over time.

To produce the data in Figure 49 the issues were categorised as in table 3. The categorisation was done retrospectively and the issues were a mixture of issues extracted via the github API and added manually following a manual eview of emails and other documentation over the lifetime of the project. The categorisation draws on standard development practice but adds additional categories such as 'reaction' that are specific to this research.

bug	A feature produces an error message, or is not working as it should
change	A feature worked as expected, but its functionality needed to change once exposed to use
devel	A task related to the technical environment eg. server maintenance, code repository
enhancement	A feature works as expected, but additional functionality was necessary or desirable
feature	A new piece of functionality
reaction	A change in the external operating environment provoked the need for a change in the system
refinement	Refining an existing feature
research	Looking at possibilities for how new features could be implemented
support	Answering questions or providing documentation about how to use hublink
upgrade	Routine upgrades provided by the Drupal community

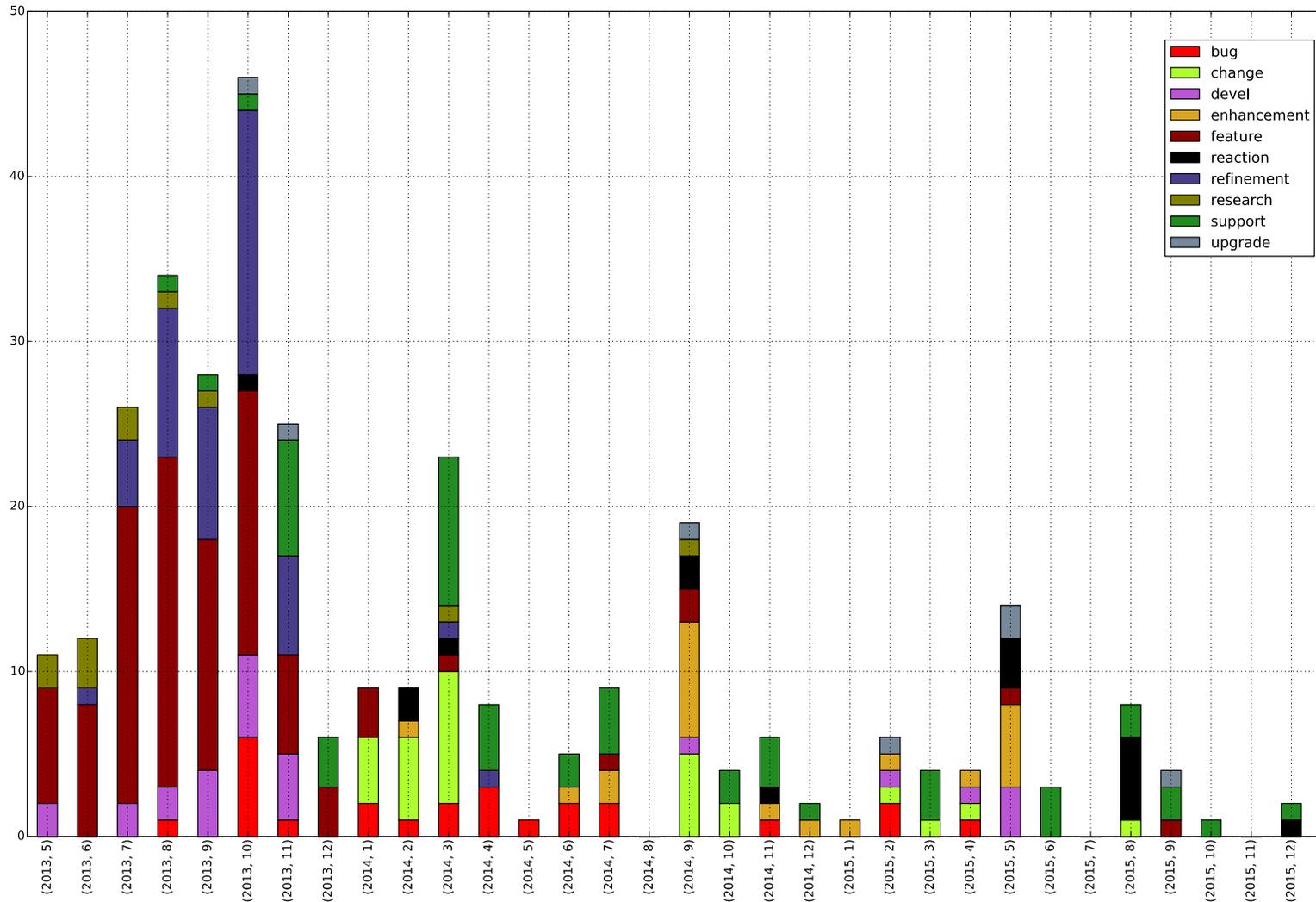*Table 3: Categories for issue types used to create figure 49*

Figure 49: Types of task, grouped by month (x axis), and category of task (colour). Y-axis shows the number of issues.

Figure 49 shows the different kinds of tasks that needed to be done and how they were distributed across time. The tasks are grouped by month. Each different colour corresponds to a different type of task as shown in the key. The height of the blocks correspond to the number of tasks.

The chart illustrates the progress and changing patterns of the tasks undertaken during the project. During the development phase time was spent on building the infrastructure (devel), creating new features and doing research. During the development period, we see that features were refined – ie incrementally brought closer to the desired behaviour. These gradual refinements were part of the prototyping and testing process. During the transition and design in use phases features were fixed or changed, but few were added. Support requests (green) - which include producing documentation - dropped off as the project progressed but picked up again after the departure of the project co-ordinator who had been part of the design and testing process. There are two peaks, in September 2014 and May 2015 when requests were grouped into additional development 'phases'. Bugs appear after these peaks, showing some amount of instability caused by these changes.

A revealing result is that as the project progressed more of the kinds of tasks indicated in black occurred. These are tasks that needed to be done in reaction to changes in the operating environment that were unrelated to our technology or even our own organisations. Two of these groups of changes have been related to changes in the reporting requirements of the commissioning organsation, and for one (as described in case study section 5), we had to adapt to a new national law called "The Care Act". These changes are described qualitatively in case study sections 4: Design after Design and 5: The Long Haul. The need for such changes due to external factors are described in the literature including (Simonsen & Hertzum 2012; Simonsen & Hertzum 2008).

Throughout the project tasks categorised as 'devel' are required. These tasks are also related to infrastructuring as they refer to tasks concerned with the underlying support system of the project. Such tasks include interacting with the hosting company, setting up or changing the functional test framework (see case study section 5: The Long Haul) or tasks related to maintaing the code repository and deployment. The chart shows that these tasks are distributed across time.

In the literature review, we discuss the insight from Wulf and others that tailorability is key to the sustainability of an information system over time, as a system must be seen in a context in which changes take place and lead to the need for adaptations. As such, tailorability is another element of infrastructuring. I suggest that the data analysis from the ticket types illustrates this observation, and shows how the need for tailorability changes from adjustments in the first phases of the project

5.6.7 Source of solution: the importance of tailorability

Figure 50 shows how the issues were resolved. The aim of this plot is to illustrate changing patterns of technical support over the lifetime of the project and the potential of end-user tailorability. Assuming that changes in code can only be performed by developers but changes in configuration could potentially be done by 'leading users', we can evaluate the potential of leading user tailorability in this and future projects. We can also see where end-user tailorability might usefully be designed-in for the future.

From Figure 50 the following observations can be made: In Drupal, a high number of solutions to problems can be performed through configuration changes alone (yellow). This is significant for a small scale project for the following reasons. Firstly, they can be performed easily with low risk to the stability of the rest of the project. This is because the configurable functionality is supplied by the community and fairly well tested and documented. Via community support forums it is usually possible to find out if a change to a contributed module might have negative consequences to other parts of the system. Secondly, they can potentially be performed by non-programmers. In fact, as described in part 5.3.5.3 of the case study, there was a gradual opening up of parts of the system configuration interface to non-programmers. The category of EUD is shown in the plot to indicate tasks which were actually undertaken by the community partners. Not many of these are shown, in part because this aspect dropped off after the departure of the original project co-ordinator at which point knowledge was lost from the project (See case study part 5: The Long Haul). They are also under represented because, after some initial guidance or documentation, many EUD changes took place without reference back to the developers. The proportion of changes that require changes to the code base drop as the project goes into the long haul. External tools, shown in black, for instance FLOSS accessibility tools such as browser plugins for high contrast colour schemes, and support from the community in the form of module and core upgrades (purple) as already supplied are significant.

It is only possible to speculate how the pattens might be different in a FLOSS project that did not use PD as there is no direct comparison data available. However, one might expect the following main differences. Firstly, the number of support questions (brown) are extremely low for a new project. This is because the leading users were able to act as a first line of support for their partners in other organisations. Simple queries relating to for instance, password re-setting were all answered by the leading users and so do not feature in this plot. In a non PD project, even if training is supplied, one might expect more simple support queries. Secondly, in a non-PD project , the capacity and desire to take on the tasks shown here as 'EUD' (dark red) would be unlikely to be present. One could therefore predict more configuration changes showing in the plot later in the project (yellow), as more requests would be to make a change rather than being a request for information on how to make a change. Thirdly, in a non-PD project there would be an additional category of training. In the Hublink project training tasks were wholly taken on by the community partners, with the capacity to do so being cited by participants themselves as a direct result of the PD process (see 5.3.5.1).
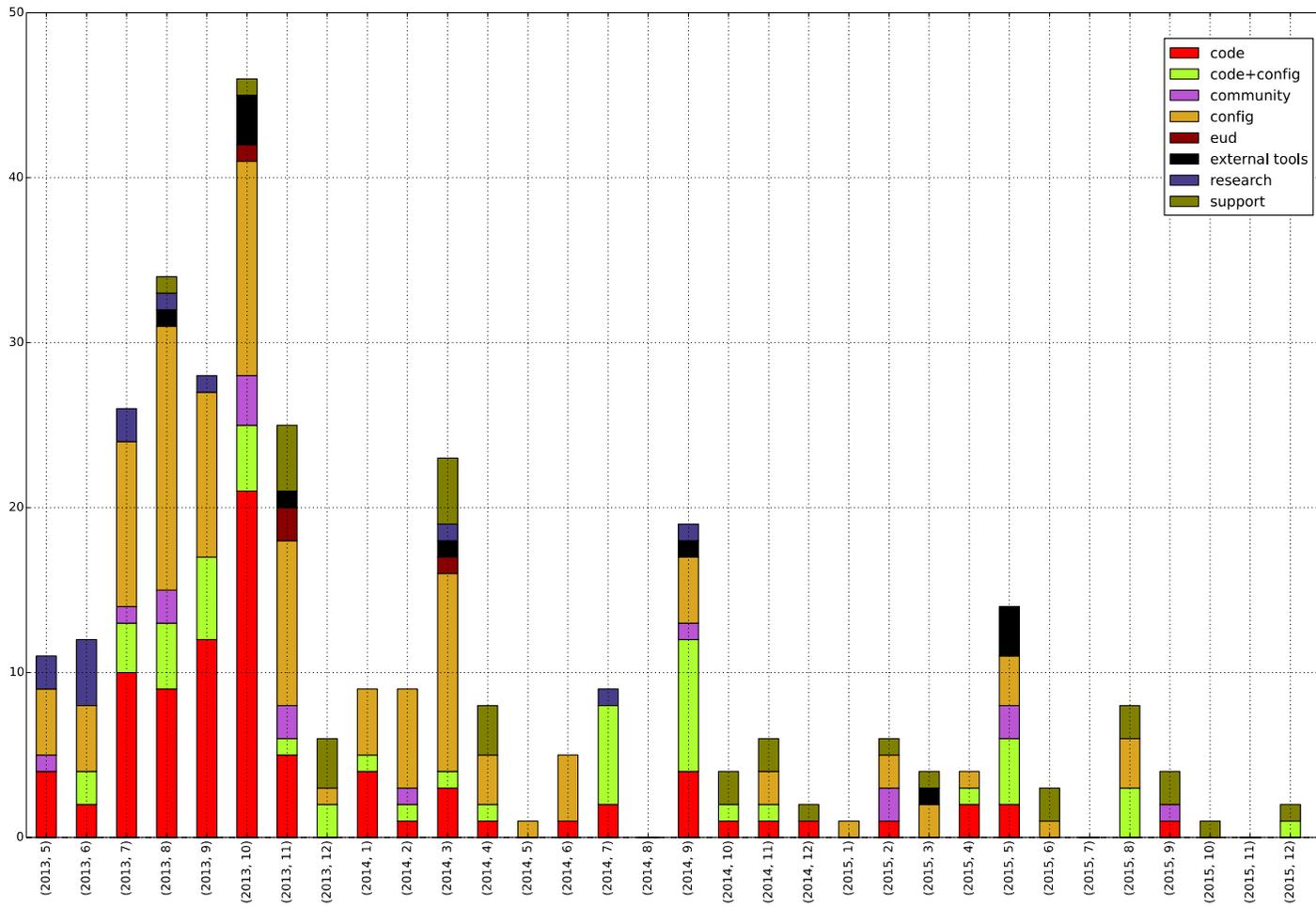
Figure 50: How the issue was solved grouped by month (x-axis), type of fix (colour), y-axis shows number of tasks

Code	A change needed to be made to the code base
Combined	A combination of code and web-based configuration
Community	The solution was available as a community contribution
config	The solution could be made completely within web configuration
eud	The solution was performed by the community partners, (usually with some guidance)
external tools	The solution could be made using some external tools eg. browser plugins for accessibility
research	The solution was finding out more
Support	The problem was solved by providing advice or documentation.

Table 4: Categories for issue types used to create figure 50

5.6.8 Conclusion

The work described in this final section of the case study is intended as a form of triangulation of the more descriptive parts of the case study. As such this evidence makes limited claims. This data is not indended as an indicator of quality - as quantitive methods might be used in a software engineering context, and they are not geared towards management tasks. Instead, they are experiments in the use of a Digital Humanities approach (Kirschenbaum 2012; Spiro 2012) in this case applied to describing a design project. Their aim is to apply data analysis and visualisation to digital data that already exists for another purpose, and to see what insights about the human-centred aspects of this development project might be gained through this technical data.

In keeping with this project as a whole the technical tools for these analyses are all FLOSS, and have been created with the help of extensive reference to community-supplied documentation. In keeping with a FLOSS approach, have taken an experimental approach, using my own programming skills to address domain problems of which I have knowledge.

5 Conclusion

6.1 Research question

The research questions for this thesis are stated as follows:

How does a PD design process, in a community context, benefit the sustainability of a project beyond the design phase, moving into the phases of adoption and ongoing use?

With secondary question:

> *What specific benefits to long-term sustainability are brought by using Open Source software?*

The conclusion of this thesis is in two parts. The first summarises the Hublink project description and the issues it raises. The second part is a summary and discussion of the findings of the thesis as a whole. Both sections refer back to the issues highlighted in the research questions.

6.2 Case study summary of findings

Section 5, the main section of his thesis, has presented an extensive project description that comprises a case study of the Hublink case management system. In the project description I describe five phases of work. The first phase was the research phase, in which no technical work was done but the scope of the work was established with the community partners through workshops and paper prototypes. The second phase, Design and Development, was the main build phase of the project in which the application was built incrementally, using two more prototyping phases to check, refine and expand the design. Phase 3 was a short but important transition phase in which the application was readied for use in a trial period, and in which practical activities by the community partners broadened and accelerated. In this phase, the partners became deeply involved with adoption and appropriation activities, using their knowledge of the application that evidence shows was built from their participation in the PD process. Phase 4 represents the first ten months of the system in use, during which time substantial adjustments and changes to make it more fit for purpose took place. Phase 5, 'The Long Haul' describe the ongoing activities that are and will be necessary for the entire lifetime of the project. These include, on one hand, adapting to unforeseen changes in the operating environment and, on the other hand, regular maintenance and oversight tasks. The final section of the case study takes a contrasting methodological approach to the previous descriptions of the project phases. In this section, digital artefacts that were produced in the course of creating the project for managing technical tasks – namely the code repository and issue lists – have been analysed mathematically and visualised using programmatic methods to discover patterns in the work processes of development and maintenance. Included in this is a visualisation of the contribution of the Drupal open source community to the sustainability of Hublink.

Throughout the project description, key theoretical themes have been referenced. The three principles of PD, having a say, mutual learning and co-creation (Bratteteig et al. 2012), plus the concept of infrastructuring - which includes tailorability and appropriation – structured the reflective sections of the case study. The insights from CI into the specifics of the community context have also been referenced.

In addition to the themes identified from the literature, the project description shows how a strong focus on values gives cohesion to this project. Hublink was a partnership primarily involving myself as researcher/developer supported through Bournemouth University/Centre for Digital Entertainment, *Real* the community partner, and Fossbox. *Real* are a locally focussed, community organisation that provides frontline services backed by a strong self-help and campaigning ethos. As a researcher, I brought an interest in PD with its commitment to using design and IT to empower individuals and strengthen community and collective activity. Fossbox focus on using open technologies to enhance social action and help community organisations to be aware of the implications of their technology choices. Fossbox plays a key role in this project as a mediator and facilitator that bridges a knowledge of technology and the advantages of FLOSS, with an established level of trust and experience within the local community organisations in the London Borough of Tower Hamlets.

The literature of CI describes how strong values such as those described above that guide the partners, in combination with resource constraints, characterise the community sector. This analysis is strongly reflected in this project. PD is also a field strongly defined by values of democracy, self-development and empowerment. Therefore there is a strong overlap between the values of PD and those of Real and its partner organisations. Reflecting the pressures that are very often present in this sector, the very impetus of this project was provided by a reduction in overall resources for the important work undertaken by all the community partners. Therefore, consistent with the insights of CI, the combination of strong shared values and tight constraints has been a hallmark of this project, showing that a large amount can be achieved by working together in this environment of strong motivation and shared concerns However, the projects narrative over a longer term has also shown the fragility of these gains.

The Hublink case study shows that many successes can be derived from harnessing the values and methods of PD. During the design process, the entire group reached a deep understanding of the details of each others work, and enough information was passed between the development team and the community partners to enable the building of an application – in a very short period of time – that was able to meet the baseline requirements. The most unique aspect – the need to manage and track work across different organisations as well as within them – was implemented with success.

The most notable outcome of the case study is the evidence that the PD process was key in facilitating the large amount of capacity built within Real that in turn engendered a strong sense of ownership, and enabled staff there to manage all of the training and adoption work among the partners. The PD process also built trust and provided an opportunity to develop both the service and the application in tandem.

The mutual learning outcomes of PD, on all sides, contributed to effective partnership working, and moreover put participants in a position to take advantage of the tailorability of the FLOSS framework used. Customisation through the lifetime of the project has proved to be essential to maintain the relevance of Hublink to its operating context, and some of this ongoing work has been taken on by the community partner. This combination of learning and technical the affordances of the FLOSS framework we used led to some amount of 'end-user development' taking place in this project, even though this was not explicitly planned for. Therefore, this research powerfully illustrates the mutual learning outcomes of the PD process, in particular their potential to enhance tailorability and thereby contribute to sustainability.

Because of the tight constraints, this project is not and cannot be offered as an exemplary PD project. Involving all of the consortium partners would have been desirable but was not possible given the resource limitations of both the community organisations and the development team. The organisational culture and management decisions of our partners, with whom we shared control, had to be constantly balanced with the aspirations of PD. However, while participation has been key to the successful aspects of this project, where participation has been absent there have been shortcomings. While it was not possible for all of the Local Link consortium partners to contribute to the design process, it has been strongly expressed in the reflective interviews that the application and its adoption would have been greatly improved if the partners been involved at an earlier stage. Meanwhile, it was observed that when key staff from Real left the organisation, a significant amount of knowledge and understanding built through the design process was lost. The problems that occurred through these shortcomings in participation underline how participation was effective and highly valued participation when present.

One of the most difficult tasks in developing Hublink has been providing easy to use methods for extracting data in a usable and useful form. Even though information has been collected in granular ways, it has not been easy for users to access and analyse the data, and lot of development effort has gone in to enabling this. This aspect have benefited from being given more attention, earlier in the process. This aspect also suffered from being determined in a 'top down' way. With our limited resources, we prioritised extracting the data required by the commissioner and gave less time and thought to what might actually be useful for the frontline workers, their organisations and their clients. We could have approached the task with the organisations' own needs in mind from the outset and, for instance, designed specifically for gathering and displaying evidence that might be useful to alter the service or inform campaigns.

Community Informatics emphasises the importance of control for communities over the technologies they use, and for this reason many CI practitioners advocate FLOSS. In this case study, it has been shown that a network of organisations support Hublink and mediate the contributions of the FLOSS community that contributes to the ongoing sustainability of Hublink. Key in this network is Fossbox, which has both brought parties together and provide a framework for ongoing support. It is important to underline that because Hublink use a FLOSS framework implemented in a standardised way, Fossbox could be replaced in the ongoing maintenance phase by a different organisation with similar skills. However, despite these pieces of the jigsaw being in place to offer ongoing technology support, Real have not felt fully in

control of the technology at all stages of the process, notably since one of their staff members with knowledge of IT left the organisation. Therefore we see that 'infrastructuring' provides an accurate description of the elements necessary to support Hublink it the community context; acknowledging both its enabling characteristics, and its fragility and contingencies.

There are clear outcomes from Hublink as a research project, but as a practical undertaking, has Hublink been a success? I do not believe there is a clear answer to that. It has been successful, in the sense that it was ready on time and it has survived 2.5 years of use. It has fulfilled the purpose to which it was intended to a large enough extent to keep it in use. It has been a reasonable tracking tool for casework and has been particularly popular with frontline workers who have good computer skills but did not have access to any electronic record keeping before. It has been technically very stable and the infrastructure has so far been effective in the sense that the kinds of failures that seriously jeopardise the service have not occurred.

However, for a number of organisations, usability has been a continuing problem with some frontline workers finding the interface confusing and unintuitive, and therefore having problems integrating it into their work. Hublink has succeeded in its aim of allowing individual organisations to both aggregate data and share information where necessary, but mostly work autonomously. It has produced quantitative data as required, but only with great effort – probably this is the set of tasks that a content management framework was least suited to. A significant achievement has been the ability to adjust to changes, such as the introduction of the care act in 2015, though care has been required to ensure that the reporting tools always reflect changes in the data input forms. The interface could have been improved, but the hours that the front-end developer could work on this project was limited by financial resources. Other more subtle factors have been uncovered through this work as well, including the added amount of potential stress and responsibility that comes with a participatively designed solution. This is discussed further in the next section.

Overall, this case study illustrates the capabilities and creativity of users, and the great productiveness of the communities of practice in both Open Source and grassroots organisations, and how combining these forces in very practical ways can create services and systems that both promote and are sustained by communities. Through thick and thin, I have observed and valued the outstanding commitment, hard work and teamwork in the partner organisations, and it is this more than anything that has made the project, both research and production, possible.

6.3 Discussion of findings

This research project has investigated key themes in PD, CI and FLOSS from both theoretical and, most importantly, practical undertakings. As a substantial and long-running project, a number of contributions to each of these areas have emerged that illustrate, add detail to, or extend the literature.

The discussions below highlight contributions to the literature, however it should be emphasised that this study is one undertaken 'through the medium of practice' (Archer 1995). The findings of this study come from a long period of collaborative work in an environment pressured and constrained by a large number of practical factors, but nevertheless the project as a whole resulted in usable software. Primarily therefore, this study brings an analysis of the literature from a practitioner perspective and its findings stem from the real-world attempt to bring the insights from the literature into dialogue with a real-world project in long-term use.

5.3.1 Participatory Design

In the Hublink project, a PD approach was explicit from the outset. From the inception of the project it was agreed with the project partners that work would proceed in a participatory way, with the fullest possible input of frontline staff and shared control over the design process. It was also made clear that production would be punctuated with reflective activities. As discussed during the case study description, these approaches were consistent in most ways with the values of the partner organisation, Real, and this underlying consistency has been a great benefit to this project.

Against this background commitment, it has been possible to investigate both tangible and intangible benefits of PD, using the reflective methods of Design Research and Action Research. Through these methods, the project's evolution and results have been thoroughly documented and iteratively re-evaluated through practitioner and group reflections.

This project confirms the overall perspective of PD, though its core values, that participation brings great benefits and added opportunities to software development in a community context. Reflections from partners in the project, including individuals with experience in larger organisations and industry practice, show that the project could not have been achieved through non-participatory methods within the constraints of the context. The resources required for a more conventional software project: generating, tracking and managing specification documents, are simply not available to an organisation such as Real. In place of these industry practices, PD methods created shared experiences through which requirements emerged and were refined, and design decisions made collaboratively. As in many PD practices, these shared experiences were based on iterative prototypes, both paper and working. The tangible benefits of these were the creation of an initial version of the system that could be put into use and then further refined in the 'design in use' phases (phases 3, 4 and 5 in the case study). However, in addition, a series of intangible outcomes of the PD were observed and which were clearly articulated within the reflective interviews.

The intangible outcomes can be summarised as the emergence of leading users from the community partner organisations, who were empowered by the PD process to lead processes of adoption and design in use. These users became connecting points between the domain of Real

and the work of developers and were crucial to the success of the project. The term 'hinge actor' is proposed to identify this pivotal role [1]. This term is extremely apt as it reflects the crucial and active nature of this connecting role, while also hinting at the possibility that it might also be a concentrated point of stress and strain.

In the case of Hublink, the emergence of these actors was unplanned, though directly attributable to the learning experiences of the PD process. Building even further on this learning was the emergence of the desire to get involved with the ongoing customisation of the system: evidence in this research shows that this desire emerges directly from involvement in the design process.

While the emergence of these 'hinge actors' had many benefits there were also negative sides to the experience of the individuals who acquired this role - as reflected in the 'hinge' metaphor. This was the increased pressure that came with this mediating role, and a strong sense of responsibility for the co-designed system when dealing with other users. This pressure led to a degree of ambivalent feelings about the system among these users, even though there was also a strong sense of pride in the achievement. We also found that this success in producing these roles also led to fragility, as these important gains were also easily lost when staff members who had been involved in the design process left the organisation.

These negatives should not be seen as failures, but should be reflected upon as new issues for PD to tackle when dealing with real-world projects and planning for sustainability. The PD literature has long shown and understanding of the the power of co-creation and shared experiences as sources of learning and self-development. However, the Hublink project shows that, moving into long term use, that knowledge need to be better shared among individuals and more firmly embedded into organisations who use the software. Similarly, while the contribution of the leading users or hinge actors is acknowledged as being crucial to adoption and ongoing use, that contribution needs to be recognised and explicitly supported by organisations who must provide support structures – for instance through partnerships with technology specialists - that help release the pressure on these individuals.

Infrastructuring has been found to be important in this study because it is able to describe the many activities and relationships and that support a project into ongoing use. It is particularly useful because it is able to incorporate intangible factors such as the emotional dimensions and the strong personal ties that are an outcome of the shared experiences of PD. These intangible factors are crucial for ongoing support, but are also contingent and fragile. In this study, infrastructuring has mostly been used reactively as a tool for analysis and description. However, the study findings suggest that PD projects that transition into use could use infrastructuring more pro-actively, as a tool for planning ongoing support. This instrumental approach may seem at odds with the critical and analytical tone of STS where it originated. However, I suggest that for the reflective practitioner (Schön 1983), who recognises these kinds of intangible dimensions, infrastructuring can be an important tool in bringing these usually

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1   The term 'hinge actor' was suggested by Dr Jose Abdelnour-Nocera as part of the discussion of this research project's findings at examination in September 2016.

hidden facets of practice to the surface, and putting them to use to improve the sustainability of future projects.

5.3.2 CI

Carroll and Rosson (2007) make a clear statement on how CI and PD are complementary. Their proposition that PD has both ethical and pragmatic benefits when deployed in the community sector has been referred to in many places in this thesis because the Hublink project amply illustrates this point. Likewise, the foundational emphasis in CI on the importance of values on one hand, and the necessity to work within tight constraints on the other has also characterised this project. CI is a practical discipline that encourages approaches based on needs but also makes clear that control over systems and data should not be compromised.   The Hublink project clearly shows the complementary concerns of PD and CI.

However, this project adds additional perspectives. Again, as a real world project, things are shown to be not always clear-cut. The Hublink project has shown that, in the UK context at least, community organisations can be a mix of professional practices and community values. While the needs-based approach, constraints and focus on common values and front line work is present in this project, there is also a top-down element. This comes from the realities of working within a funding regime based on quantitative reporting, and metrics based on value for money. The Hublink project shows a need for a pragmatic approach, and how using PD in a community context can address these very real requirements while also respecting and enhancing the community work that lies at its heart. The CI concern with control is relevant here. It can be temping for third sector organisations to buy in to proprietary systems to appear to conform to the standards of the private sector with whom they are being asked to compete. However, the Hublink project shows there is an alternative to that approach, that PD can be particularly powerful in the community context, and provide a range of tools that build positively on shared values and, via mutual learning and the emergence of 'hinge actors', enhance the capacity of community organisations to survive in an a political environment that, adverse to their own values, puts the market economy above inclusion and community empowerment.

6.3.3 FLOSS

The relationship of FLOSS and PD is a key component of this study. The production of Hublink, and indeed all of the research and production for this thesis has been wholly dependent on Open Source tools. However, the aims of this thesis go beyond demonstrating the value of FLOSS to software development in general, or making general remarks about the values shared between PD and FLOSS.

Instead, the research question aims to link PD and FLOSS in more specific ways and with a focus on sustainability. For this discussion, the use of infrastructuring as as an analytic and potentially a planning tool comes to the fore. Similarly , the linkage made in this study between

learning through shared experience and the need for tailorability are useful to build a stronger argument for the link between PD and FLOSS. These links point out new directions for how PD practitioners might engage with FLOSS communities for the benefit of both.

Through the Hublink project it has been shown that FLOSS benefits the sustainability of the project by providing, through its communities, ongoing maintenance and improvement. We have seen this demonstrated in concrete ways in the data analysis described in section 6, fig 48. Here it is shown that security and other updates are applied throughout the lifetime of the project. Unlike in a situation in which proprietary software is used, the community organisation can be reassured that there will be no financial costs or other barriers to obtaining these updates at any time in the future. We also see design in use taking place throughout the project, but particularly in its first year. This can take place without limits because there was no financial cost involved and because of the unfettered extensibility of the framework. The way that this extensibility is built in to the technical and social structure of open source projects is described in sections 3.4.4 and 5.6.5.

The case study has shown powerfully that, through the lifetime of the project, only continuous and unlimited customisation has made the software able to be transformed into a usable system for the whole of the consortium. This ability to continue to customise in an unconstrained way contrasts with propitiatory systems in which customisations and the support and information to make them are limited, can incur unpredictable and uncontrollable costs, and are geared towards the production of commercial product rather than community need. Thus we see that design-in-use, which we have seen is is key to sustainability, takes on distinct characteristics if FLOSS is used. FLOSS ensures that these phases are characterised by unfettered use and investment in individuals and FLOSS communities with whom supportive partnerships can be made and continued control over data and infrastructure is assured.

Moving on from the concrete activities of maintenance, the case study part of this thesis has shown how creating spaces for shared experiences and informal yet focussed processes of requirements gathering can be a powerful enabler to create software in a PD context. The literature review part of the thesis has shown that informal, experiential processes are also features of FLOSS projects. The work of Scaatchi and Scaatchi and Alspugh in particular focus on how FLOSS projects can be successful despite their non-conformance to other industry practices around requirements gathering. Instead, they argue that shared experiences of developers lead to shared 'mental models' (Alspaugh & Scacchi 2013; Scacchi 2002), and describe how informal processes harness these shared mental models in the production of further developments of the software. Meanwhile, other studies, for instance Nichols and Twidale (2003) show that FLOSS projects tend not to conform well to usability standards used within other industries. However, I argue that FLOSS projects are not products in the same way as commercially produced, proprietary equivalents, and therefore cannot be compared in some ways. FLOSS projects are ongoing processes that emerge according to shared needs and through their communities of practice in contrast to commercial products that are driven by market research, product development and business modelling. FLOSS communities comprise mainly of developers and therefore it should not be surprising that they will have less consideration of the 'end user' who is not part of the community, so while there might be a

structural explanation for the lack of emphasis on user experience in FLOSS and straightforward comparisons with proprietary software cannot be taken at face value, user perspectives are often lacking in FLOSS projects, and it would be fruitful to address this.

Therefore, I suggest that this research project's illustration of the productive power of PD in a community context also points toward new ways that PD and FLOSS might come together to create a different approach to developing usability. This study has identified the importance of what we have termed leading users or 'hinge actors'. These users have been shown to emerge from the shared experiences created by PD processes, and have gone on to become crucial actors in adoption and ongoing development of the software within their organisations. Extending this observation, I propose that these users also have the potential to also become crucial actors in FLOSS projects, bringing an informed user perspective and understanding of context of use, coupled with technical understanding. Therefore, through its well-established methods and the actors they produce, PD can engage with FLOSS communities by bringing users and developers together in structured, creative and ethical ways; thus addressing some of FLOSS's issues with user experience, while also providing better technologies for PD.

Finally, issues related to sustainability are also addressed by drawing attention to replication as a strategy for ensuring sustainability. FLOSS can be replicated and scaled in ways that are unencumbered by licensing and other legal and financial constraints and can therefore be fully under the control of the PD and community partners.

5.3.4 Implications for PD methods

The discussion on PD and FLOSS shows that FLOSS is able to provide support for PD with both human and technical resources, with particular benefit to design in use and sustainability. There are several implications therefore for PD projects that use FLOSS which, I suggest, should be made more explicit and receive stronger emphasis in PD practice.

Firstly, PD methods should include a technology evaluation phase. This technology evaluation would address the best route forward for a technology project, and document a rationale for the decisions made about technologies adopted. This evaluation phase happened in the Hublink project in a mostly implicit way, but the project would have benefited from the this phase being more explicit and transparent, well documented and shared with the community partners as the start of the mutual learning process.

A number of questions should be asked in this evaluation phase to ensure that technologies adopted are suitable for a PD design process the planned model for design-in-use and ongoing sustainability. For example: how suited is the software to incremental prototyping? And, how suited is it to ongoing customisation? This evaluation phase should also look at the supporting FLOSS community and extent of similar usages. Is there a strong community that will support the project through its planned lifetime? Are their similar usages? Are there available

individuals locally from the FLOSS community who can support the intended usage? Additionally, it should be considered if the planned PD project has potential to give back to the FLOSS project, thus helping secure its own future by strengthening links with the community.

Secondly PD projects should explicitly plan and strengthen mutual learning activities that enable tailorability, including producing documentation and learning materials that can have a sustained life among the users and embed the mutual learning of PD firmly within participating groups or organisations.

Finally, this research raises questions about participation itself, the roles of different team members and how to plan a sustainable infrastructure. Through its use of infrastructuring as an analytic tool it is shown that sustainability is dependent on a complex and fragile set of relationships that should be mapped, tracked and amended through the lifetime of a project. Therefore, this research suggests that infrastructuring could be seen as a practical endeavour, that can be added to the already rich toolkit of PD methods.

6.4 Further work

This research project has highlighted a number of issues that merit further work; suggesting developments relevant to practice, and also suggesting some conceptual/ theoretical threads that could be taken further.

The case study has powerfully illustrated the potential of harnessing the learning gains from a PD design process into production, especially that related to tailorability. In future work, processes could be designed and tested so that the mutual learning in design is more explicitly directed towards embedding that knowledge, while explicitly creating and supporting what in this study we have called 'leading users' or 'hinge actors'.

However, while flexibility and tailorability have been key in keeping this project relevant to its overall purpose, but there has been a degradation of quality because of this. This is an issue that has been highlighted in the literature, for instance Ko et al who point out that end user development can degrade quality (2011) , and Baxter & Sommerville who suggest that the sociotechnical approach needs to be better integrated with more standard software engineering processes to be more widely accepted (2011). Further work could look at the topic further, and within the iterative, prototyping methods of PD, take a pragmatic approach, possibly considering the use of 'throwaway' code, that is code that is re-written for production after the iterations are over to maintain quality.

Within academic concerns, this study has provided an opportunity to experiment in two different areas. One is in the presentation of the case study which I hope can contribute to the ongoing exploration within PD and practice based research more generally in how to write up

PD projects and present them in ways that are consistent with PD values, including being accessible to participants (for example Light et. al. 2016). Secondly, I have touched on the use of a digital humanities approach to mining the data gathered as part of the production of this project, using the code repository and issue tickets as data to be explored with computational methods. These approaches could be expanded and extended.

Finally, this research, like much in PD, brings up a number of questions around participation itself. The research suggests that different kinds of participants can take different kinds of roles, not only in design, but also in the 'infrastructuring' activities that are part of sustainability. By foregrounding shared experiences and connectivity between areas of expertise, this research points to new ways that the role of developer can be defined while also making an encouragement to further consider the role of what has been called 'leading user' or 'hinge actor' in this research. This set of findings contribute to work that has been previously developed including research on 'lead users' (Hippel 1988), 'gardeners' (Gantt & Nardi 1992) and 'implementation mediators' (Shidende & Mörtberg 2014). Further results of this study could engage with and extend these related discussions.

6.5 Conclusion

In this thesis I have presented the results of a three year collaboration between myself, a developer, and a community-based organisation Real, facilitated through Fossbox CIC. The collaboration has consisted of the design, development, implementation and ongoing support of a case management information system, Hublink. The project has been undertaken using PD principles, identifying the key values of PD as "having a say", "co-creation" and "mutual learning" (Bratteteig et al. 2012). These values have permeated all aspects of the project, from design into production and ongoing use, while also informing the research methods and the project presentation.

After providing some background information, a literature review surveys the socio-technical approach in general and PD in particular to describe the initial underpinning of the approach and the practical work. The review goes on to look at the concept of infrastructuring, including tailorability and appropriation. These concepts prove to be extremely useful conceptual frameworks that helped to understand and describe the practical work. The review also surveys CI, which puts Hublink within a bigger frame of community-based IT projects; helping to identify its difficult issues and linking it to common concerns across grassroots organisations of many different kinds. Finally, the review surveys FLOSS, identifying the important characteristics of FLOSS practices and technologies and how they interrelate with PD and CI. Extensibility, generativity and communities of practice emerge as key characteristics of FLOSS that link across all the areas of concern in this research.

The main part of the thesis is the Hublink case study. Through a deep description including practitioner and participant reflection, the study shows that the mutual learning aspect of PD

contributes to sustainability through the ability to undertake adoption and ongoing customisation tasks. The qualitative case study description is triangulated by data analysis performed on tools such as the Git code repository, that are used in the software production. These verify and extend the description of how FLOSS communities contribute to sustainability through maintenance, and also show how tailorability is a key component of sustainability. The thesis concludes with a discussion of the findings of the study, again structured by the key themes of PD, CI and FLOSS.

In this study, I suggest that sustainability can be analysed through the framework of 'infrastructuring'. Infrastructuring describes the diverse, social, interdependent and dynamic nature of deploying an IT system into ongoing use. An infrastructuring perspective allows us to value appropriation and maintenance, and the continuous customisability that the study shows is necessary to sustain an IT system over an extended period of time. The infrastructuring perspective also brings to light the importance of mutual learning and human relationships in sustainability and encourages us to value and support these intangible aspects.

Infrastructuring is a particularly useful analytic framework in this case, as it is able to include the contribution of FLOSS. Maintainability and extensibility, which are key features of FLOSS, also emerge as essential elements of infrastructure. Therefore, via infrastructuring, we are able to connect PD and FLOSS in precise and practical terms. FLOSS provides a technical underpinning for community/PD projects in which ongoing technical support and tailorability is essential but within which resources are limited and control needs to be maintained. FLOSS also ensures unrestricted use to allow ongoing change, and possible scaling and replication under community control. Meanwhile, PD provides the shared learning experiences that build capacity for community partners to take control of their tools. Through this capacity, they can also potentially participate in FLOSS communities, thus shaping both software and use for mutual benefit.

The case study description has also shown how shared experiences drive design in PD, and that in some respects this echoes the informality of design processes in FLOSS. Meanwhile the unfettered extensibility of FLOSS makes it useful and appropriate for experimental and prototype driven iterative processes. PD already benefits greatly from FLOSS through its provision of customisable, maintainable tools and this research suggests that PD could reciprocate by helping FLOSS expand its communities of practice and user constituencies through its well established participatory methods.   One outcome of this research is a recommendation that the evaluation of available FLOSS software should be seen as integral part of any initial investigation the context and problem space of a PD project, and this should include researching the community of practice of a potential FLOSS partner project and the possibilities for a reciprocal relationship.

A number of additional concerns have emerged through this work that open up lines of enquiry that can extend and improve PD and contribute to software design and sustainability in general. One line of enquiry is how the roles of both developers and users could be redefined in the face of tailorable FLOSS applications such as Drupal that was used to create Hublink.

The emergence of a role that is termed 'leading user' or 'hinge actor' in this research has been a key finding, showing how the mutual learning outcomes of PD can create new roles that bridge technology development and domain expertise and which are crucial for long-term use. Moreover, facilitating the development of this role has the potential to expand and diversify the developer community, as well as provide new opportunities for domain experts to develop and use knowledge or aptitude in computing. However this pivotal role also has the potential to become a focal point of stress and pressure, and therefore individuals who take on this role need to be well supported. A second and related implication for PD practice identified in this case study is the necessity to find ways to embed the gains of mutual learning more firmly within organisations to improve sustainability and support these actors. This would include finding ways to purposefully and transparently prepare users for tailoring tasks throughout the design process and capture the knowledge gained through the PD design process.

Overall, these threads point towards developing a number of different ways to bridge domain expertise and development, in the context of software development tools such as Drupal that lend themselves to forms of 'end user development'. They also point towards the extension of infrastructuring from an analytic tool into a pro-active planning tool that could be used to map out, organise and monitor the necessary conditions for sustainability.

This research project has presented many challenges. Producing Hublink itself was a large undertaking for a small team in a condensed timescale. The context was pressurised by the limited resources and uncertainty that characterise community-based VSOs. Finding suitable and practical research methods has also been challenging as these needed to be both consistent with the values of PD but also realistic to apply, especially as in this collaboration priority must always be given to the production and ongoing robustness of Hublink. Even writing this thesis has presented challenges in identifying a format and finding a voice that accurately reflects the collaborative nature of the project and that is is also relevant and interesting to participants. Throughout each of these challenges I have benefited from the generous and unwavering support of the partners in this research, in particular Mike Smith, Karen Linnane, Cathie Duncan, Ailidh Macloed and Edward Pickering from Real, and Kate Lomax and Paula Graham of Fossbox, all of whom have reviewed the case study and conclusions of this research, and with whom it has been a privilege to share this work.

6.6 Afterword

Contributions from this research have been presented to the PD community in the following peer reviewed publications as follows. I would like to acknowledge and thank the reviewers and editors whose comments have contributed greatly to the development of this research and this thesis.

Haskel, Lisa, and Graham, P. "Hublink: a case study in participatory design and open source in the third sector." Proceedings of the 13th Participatory Design Conference: Short Papers, Industry Cases, Workshop Descriptions, Doctoral Consortium papers, and Keynote abstracts-Volume 2. ACM, 2014. doi: 10.1145/2662155.2662237

Haskel, Lisa. "Double the Trouble or Twice as Nice?: Defining Participation for Practice and Research." International Journal of Sociotechnology and Knowledge Development (IJSKD) 6.4 (2014): 18-26. DOI: 10.4018/ijskd.2014100102

Haskel, Lisa, and Graham, P. "Whats GNU got to do with it? Participatory Design, Infrastructuring and Free/Open Source Software" Proceedings of the 14th Participatory Design Conference: Short Paper. ACM, 2016. doi:10.1145/2948076.2948090

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Artful Integration: Interweaving Media, Materials and Practices, pp.152–161.

Appendix 1: Full set of paper prototypes

I AAplus Consortium Management

Caseworker Notes

Client: Susan Robinson

Access needs: Not telephone, difficulty with stairs
Impairments: Hearing impaired, mobility impaired
Preferred language: English
Full information about Susan→

Issue: Housing Advice

> Issue Summary: Susan can no longer manage the 3 flights of stairs to her flat and needs to move to a ground floor flat.

Issue opened: 20 June 2011

Contact Notes: This issue

date	duration	location	with	summary
21 Feb 2012	20mins	Telephone	John Brown Housing Officer	Susan is on the transfer list. She can expect to wait approxiamtely... (read more)
11 Dec 2011	1hr 30mins	Client's home	Susan Robinson (client)	Visited Susan at home. She showed me the steep stairs leading to... (read more)
10 Dec 2011	2mins	Text message	Susan Robinson (client)	Confirmed following day's visit
11 Dec 2011	20 mins	Telephone	Sarah Jones (client secondary contact)	Discussed Susan's housing issues and the timescales required... (read more)

Showing most recent 4 contact notes. More notes →

Create a new note →

Contact Notes: Other issues
Please contact the relevant caseworker for details

date open	date closed	organisation	Caseworker
30 June 2011	31 June 2011	Deaf UK	Julie Green
11 Feb 2011	still open	Tower Hamlets Law Centre	David Blue

Showing all other notes

Figure 51: Prototype 1: project

I AAplus Consortium Management

You are logged in as John Jones
(Referral worker)

New client

Log Out, John →

Contact information

Name :   Jim Snow
Address : 27 Tower Hamlets Road E8 6FB
Secondary Contact : Laura Rain   Role: appointee   Show secondary address→
Enquiry type : Information ✓   Advice ✓   Advocacy ○
Impairment : Sensory disability (hearing impairment) ○   HIV/Aids   ○
               Brain injury   ○   Autistic Spectrum   ○
               Young people in transition   ○   Physical disability   ○
               Older people (not organic mental health) ✓   Learning disability   ○
                                                                          Sensory disability (visual impairment) ○

Languages:

Bengali
Sylhetti
Somali
Urdu
Punjabi
German
British Sign Language

Source of referral:

Self
Carer
Family or Friend
Physical Disability Team
HIV Team
Mental Health Team
Sensory Impairment Team
Children's Team
Hospital Social Work Team
GP
Voluntary Organisations
Other

Access Note : Short term memory problems
              Add access note: →

Edit contact information →

Referral 1

To: Alzheimers Society
Note : Mr Snow requires support for his legal arrangements in respect of
          his increasing disability in respect of .... (read more)
Date: 13 March 2013

Referral 2

To :

Alzheimers Society
Deaf Plus
Age UK
Real
T H Law Centre

Note :

Send referral

Add another referral →

Figure 52: Prototype 2: referral

I AAplus Consortium Management   You are logged in as John Jones
                                      (Referral worker)

Organisation Search   *Log Out, John* ➜

You searched for: *Dementia*

Active Filters
(-) advice (Type)

Change your keyword

(dementia)

Filter by type

Information   ○
Advice   ☑
Advocacy   ○

Filter by Domain of Service

Housing   ○
Benefits   ○
Advocacy   ○
Advice   ○
Employment   ○

Filter by Impairment

Hearing impairment)   ○
Brain injury   ○
Young people in   ○
Transition
Older people   ○
HIV/AIDS   ○
Autistic spectrum   ○
Physical disability   ○
Learning disability   ○

Age UK

Age UK aims to improve later life for everyone through our information and advice, services, campaigns, products, training and research... (read more)

Domains of service :   *Advice, Advocacy, Benefits, Housing*

Type: *Information, Advice, Advocacy,*

Status: *Consortium member*

Alzheimers Society

Alzheimer's Society is a membership organisation, which works to improve the quality of life of people affected by dementia in England, Wales and Northern Ireland... (read more)

Domains of service :   *Advice, Advocacy*

Type: *Information, Advice, Advocacy,*

Status: *Consortium member*

MIND

Mind is the leading mental health charity in England and Wales who works to create a better life for everyone with experience of mental distress. ..(read more)

Domains of service : *Advice, Advocacy,*

Type: *Information, Advice, Advocacy,*

Status: *Consortium associate*

IndependentAge

A philanthropic organisation providing financial support and friendship for older people (previously known as RUKBA)... (read more)

Domains of service : *Advice,*

Type: *Information, Advice,*

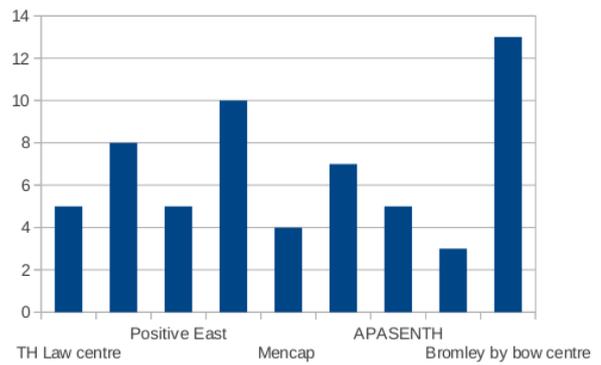**Status:**   *Community organisation*

Figure 53: Prototype 3: search

I AAplus Consortium Management

Management Reports

Enquiries:

Last 7 days
Last 14 days
Last month
Last year
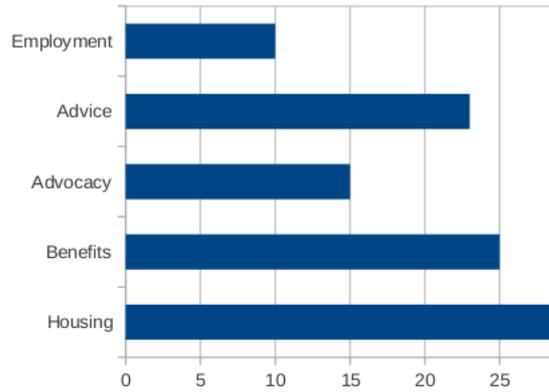
Download in CSV format →

Referrals:

Last 7 days
Last 14 days
Last month
Last year

Download in CSV format →

Enquiry until First visit:
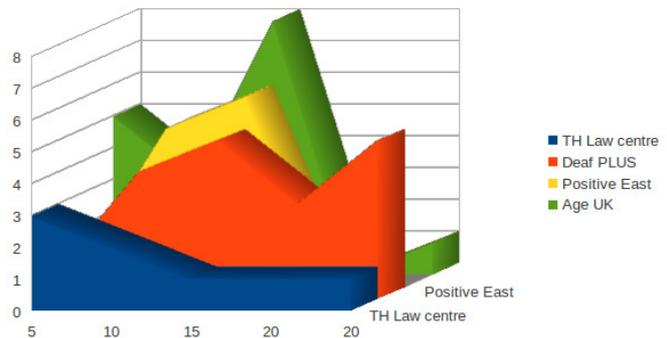
Download in CSV format →
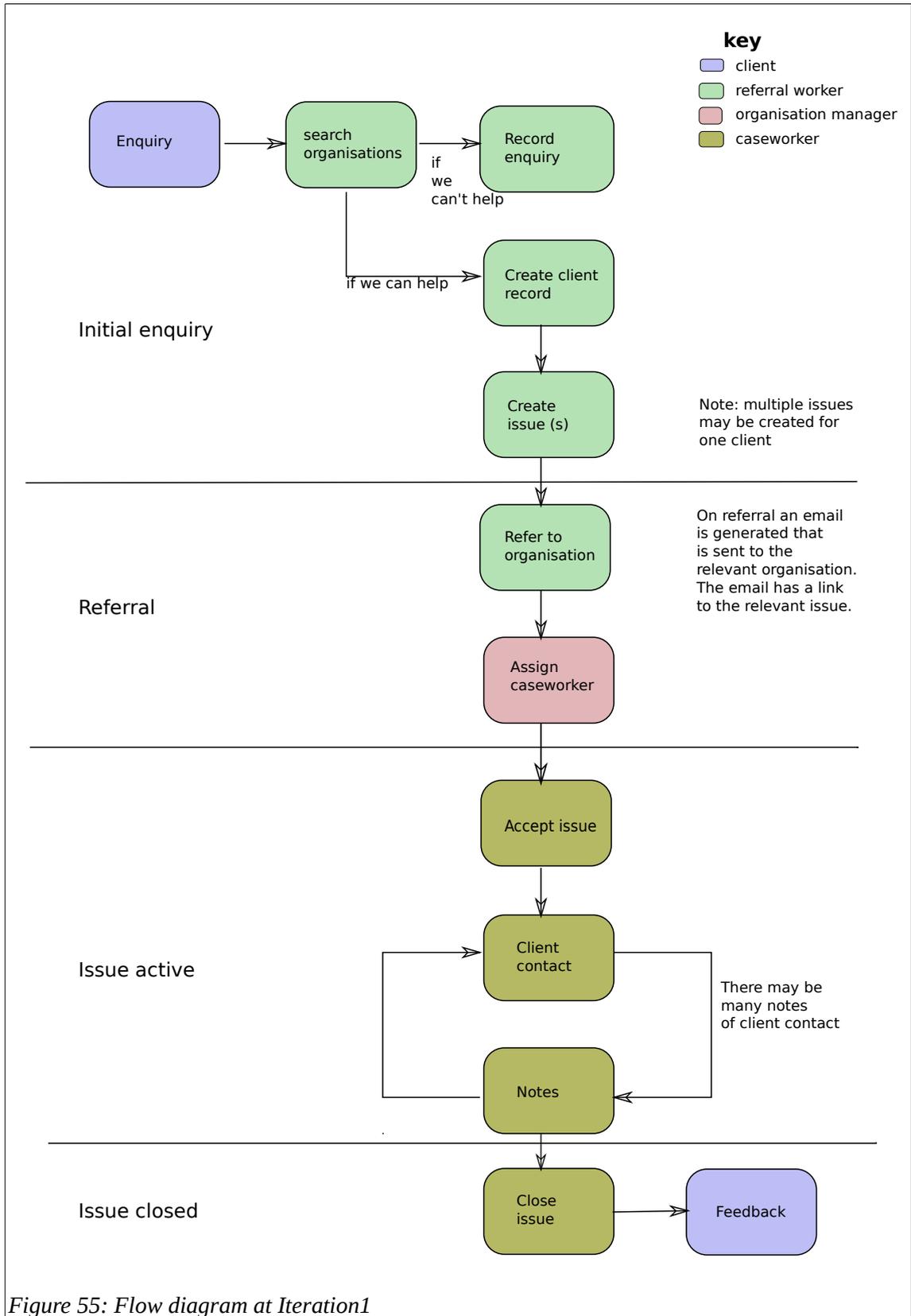
Figure 54: Prototype 4: management reports

223

key

client
referral worker
organisation manager
caseworker

Enquiry

search organisations

if we can't help

Record enquiry

if we can help

Create client record

Create issue (s)

Note: multiple issues may be created for one client

Initial enquiry

Refer to organisation

On referral an email is generated that is sent to the relevant organisation. The email has a link to the relevant issue.

Referral

Assign caseworker

Accept issue

Client contact

Issue active

There may be many notes of client contact

Notes

Close issue

Feedback

Issue closed

Figure 55: Flow diagram at Iteration1

Figure 56: Project worker dashboard showing top

Appendix 2: Larger screenshots from section 2.2

Figure 57: Client search page (some text is sanitised for confidentiality)

Figure 58: Manager's dashboard showing referrals waiting and critical dates

Figure 59: Section of note form

Filtered search shown here with 2 filters active as example

Hublink

Dashboard   Groups   Logout   My account

Enter a keyword (optional

Optional keyword
(searches only in titles
For now)

Search

Current search

Filter by content type:
- [v] Enquiry

'active'
filter:
uncheck
to
remove

Search found 39 items

- [v] Enquiry
- [v] REAL-Advocacy

'active' filter: uncheck to remove
(can be done here or in filter block)

Filter by teams w
see this record:
- [v] REAL-Advocacy

ou may enter a keyword, or use the filters at the left to narrow your search. You may need to click the block
tles to reveal available filters. Clear your filters by unchecking the box. The orange figures show the numbers
of matches to your criteria.

Filter by service:
- Information (38)
- Advice (1)

Orange numbers
shows
matches
on active filters

Date last edited	Team	Title	Date closed	Date opened	Domains of service
14/07/2015 - 11:34	REAL-Advocacy		Tue 14 Jul 15	Tue 14 Jul 15	Benefits
13/07/2015 - 18:03	REAL-Advocacy		Mon 13 Jul 15	Mon 13 Jul 15	Benefits
09/07/2015 - 16:39	REAL-Advocacy		Thu 9 Jul 15	Thu 9 Jul 15	Other
26/06/2015 - 15:23	REAL-Advocacy		Fri 26 Jun 15	Fri 26 Jun 15	Leisure
26/06/2015 - 11:23	REAL-Advocacy		Fri 26 Jun 15	Fri 26 Jun 15	Housing
17/06/2015 - 16:50	REAL-Advocacy		Wed 17 Jun 15	Wed 17 Jun 15	Travel
17/06/2015 - 16:21	REAL-Advocacy		Wed 17 Jun 15	Wed 17 Jun 15	Benefits
17/06/2015 - 12:17	REAL-Advocacy		Wed 17 Jun 15	Wed 17 Jun 15	Travel

Filter by domains of
service:
- Benefits (23)
- Housing (7)
- Other (6)
- Social care (4)
- Travel (2)
- Financial advice (1)
- Leisure (1)

Click on any filter
To further narrow the
selection

Filter by date changed: +
Filter by enquiry status: +
Filter by date closed: +
Filter by date opened: +
Filter by the organisation

Social

Click on the block headings to
Reveal more filters, or to close
To make more space in the column

Further down you will see some special filter blocks that have titles
like this (ie. with 'client >>' in the block title):

Filter by client »
impairments: +

These are special because they allow you to find
numbers of matches or filter by clients attached to
projects or enquiries eg.
Find number of benefits projects with clients with specific
impairments

*Figure 60: Documentation of faceted search application. Orange numbers show number of
records matching the current filters.*