Boundary Spanning to Overcome Knowledge Boundaries in Platform Ecosystems: The case of DHIS2 Rwanda

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Abstract

Larger information systems covering multiple user-groups and reaching users on a global scale has in recent years taken the form of generic enterprise software (Bansler & Havn, 1996). The generic software package is often managed in the form of a platform business model, and involves a platform sponsor, complementors, and end users (Rickmann, Wenzel, & Fischbach, 2014). Generic enterprise software (ES), often facilitated through the logic of digital platforms are now well established. Its impact on the global market is hard to go unnoticed, seeing that four of the largest firms in the world are all platform companies (Bonina et al., 2021). The same model can also be applied to the health sector, using platform logic to facilitate for local innovation. District Health Information System 2 (DHIS2) is a digital platform that delivers generic enterprise software, serving its complementors with core software from which they scale and implement, and even build relevant and useful applications on to the core. Complementors to these systems, often referred to as implementation specialist groups (ISGs), assist in expanding the reach of the platform, while also contributing to further development of complementary applications.

In this thesis, following a on a one-and-a-half-year-long engaged scholarship following and partaking in the development of a software project for and with DHIS2 stakeholders, HISP UiO, and HISP Rwanda. The software project included online collaboration and a fieldtrip to Rwanda. Through our findings we discuss three main considerations for upcoming boundary spanners to leverage from, these contributions are as *early establishment of what to be expected from the stakeholders, prepare for instances with shortcomings in communication*, and *be clear in what the spanners' objectives are, early.* Further, we propose a model from which vendors of innovation platforms with a large ecosystem containing vastly heterogenous complementors can use, one that goes beyond the traditional scope in ES platforms. In the model, we classify KBRs into two categories: *Assumed known*, and *vendor distributed*.

Acknowledgements

First and foremost, we would like to thank our supervisor Silvia Maseiro who´s positive spirit has never seized to diminish. Thank you for always being reachable, no matter where you were in the world. You have been invaluable to the progression of our thesis! We would also like to give a huge thank you to our co-supervisor, Magnus Li, who always had his door open for us when we needed to chat about our thesis, and for the occasional never-ending chats about things such as what innovation actually means.

As we were lucky to travel to Rwanda, we have to give a shoutout to the HISP team in Kigali. For us, it was a true pleasure to be a part of their developer team and their warm hospitality is one of rarity. Kigali offered us an incredible journey, not only for our study, but also at a personal level. We hope to see you again soon – Niwane!

During our time at University, the Design Lab has truly been our greatest asset. Even though the lab facilitates for research, our greatest joy has been to be a part of a community filled with positivity, laughter and engaging debates. It´s been a blast, but all good things, must come to an end.

To our friends and families. Thank you for your continuous encouragement and endless support. Mikael, would like to share his utmost gratitude to my partner Elin. Thank you for always being there when I come home, and for all the conversations we share about everything other than the master's, giving my thoughts some rest. Thank you for having kept up with my stressful persona during this time.

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1 Introduction

Developing user-friendly applications to support Health Management Information Systems (HMIS) in low- and middle-income countries can prove an important role in empowering data management and enhancing decision-making. HMIS users in eastern Africa, while up until recently, more familiar with analogue information systems are now being taught how to interact with digital artefacts serving the same purpose as their legacy paper based one. Additionally, IT-consultants and developers in the same geographical areas are being taught how to design and develop such applications, working as complementors to the digital HMIS. This type of Information System (IS) functions not only as a service for health workers, it increasingly serves the health sector as one large assemblage of technical features and organizational attributes, while also facilitating for capacity building amongst its users and stakeholders. However, implementing such a body to the health sector in low- and middle-income countries can bring complex challenges for both social and technical capacity.

1.1 Software Engineering evolution

Software engineering has in recent years experienced a shift in its managerial methods. With growing usage of '*Agile Methodologies',* development teams from small to large-scale organizations have implemented new practices from which they structure their development process. Agile methods are being implemented to structure workload and resources more iterative, with focus on flexibility. Some examples of this relatively new working process are 'Scrum', 'Kanban', and 'Extreme Programming (XP)'. On the other hand, the planned and pre-emptive approach refers to the more traditional models, with examples such as 'Waterfall Model', 'V-Model', and the slightly more adaptive 'Spiral-Model'. A growing trend has been to scale and adapt the agile approach in combination with traditional tendencies to best fit the organization and project. Scaling process models has in recent years played an increasingly vital role in software development for both large-scale and smaller IT-projects in the western part of the world, and though for long, these practices have been limited to the western and industrialised part of the

world, they might now gradually find their way into the global south. However, studies exploring development processes for digital platforms and more so for those branching towards '*Information and Communication Technology for Development'* (ICT4D) are underrepresented in IS. With a narrower perspective, the '*Software Development Life Cycle*' (SDLC) for software projects in novice IT-communities lacks in literature, and specifically through the lens of digital health platforms.

1.2 SDLCs on digital platforms for development research

Even though software development rests with great empirical foundation in IS research, with ICT4D also rising in relevancy, its conjoined phenomenon still resides with challenges yet to be explored with approaches in which the literature benefits. Assumably, this is due to it being relatively new as a research object, but perhaps also due to its intricate and complex nature. But with growing presence of digital HMIS' (DHIS2) in the global south, more studies on this topic are needed to further develop an understanding on the phenomenon.

Information systems research has responsive to the organizational shift (i.e., use of agile methods) applied a larger focus on the impact of agile SDLC's in software projects. Unfortunately, as the previous section explains, this debate is not yet – at least not to the extent in which it produces desirable outcomes – covered on or applicable for software projects in the global south. In this regard, there lies opportunity to generate important knowledge when researching the socio-technical attributes of systems and software development for novice IT communities. First, in a fashion such as to build an understanding of differences in technical capacity and social work practices in countries from developing to industrialized. But further, to research what must be in place to implement such an artefact (i.e., SDLC) through boundary spanning. Ideally, researching this topic should be conducted using deeply engaged methods. And with participation in design and development of platform-complementing software in low- and middle-income countries, scholars can extend IS literature on this yet underexplored phenomenon. Such studies, using deeply engaged methods in their research, allow for

scholars to observe and partake in complementors' software practices. In doing so, the studies can identify shortcomings that are of interest not only to the scholar, but with immediate interest to the engaged organizations. As a result, improving development practices in DC organizations using workshops and other tutoring, simultaneous as contributing to the literature.

1.3 Design labs to facilitate for boundary Spanning

Methods through engaged scholarship enable collaboration with practitioners in addressing problems in real-world situations (Li, 2021). The design collaboratorium is a common ground in which various participants holding a share in the same use context engage together in a design process Bødker & Buur, 2002). The lab promotes engaged scholarship and facilitates the type of collaboration needed to expand our understanding of SDLCs in novice IT communities. These labs enroll students from local/global levels to study mostly similar phenomena, allowing for a broader perspective and with greater capacity when researching. DHIS2 vendor and research group HISP UiO adopted this concept when establishing their own '*DHIS2 Design Lab*'. The DHIS2 design lab allowed us as researchers to explore within well-established relations between vendor and ISGs. Something of which would be tough and if not impossible without.

1.3 Research Question

Our thesis aims to extend literature on boundary spanning for complementors in a platform ecosystem by addressing the following research questions:

RQ1:

> *What are challenges for facilitators of boundary spanning activities in a digital platform ecosystem*

Boundary spanning refers to the activity of knowledge sharing between organizations in an ecosystem. *Facilitators* refers to individuals organizing and facilitating for knowledge sharing.

This thesis presents the case of DHIS2 complementors HISP Rwanda. The focus concerns addressing two major challenges for digital platforms in DCs. Firstly, we describe observed challenges related to disrupting software development processes and practices related to app development on a digital innovation platform Second, we unravel challenges for boundary spanners when ISGs practice misuse of boundary resources complementing a digital innovation platform.

2 Related Literature

This thesis aims to explore the challenges with knowledge boundaries found in platform ecosystems, and what role boundary spanning can play in this environment. We build on and aim to extend the literature stream concerning boundary spanning within a digital platform ecosystem. We do so with a deductive approach, in which literature on platform ecosystems an ICT4D act as building blocks for our understanding of the project environment. Then we position boundary spanning within this environment and use this as our theoretical lens for the research.

This chapter is organized as follows: First, we break down concepts and theories related to generic enterprise software. Second we define the term *digital platforms*, *boundary resources* (BR), and *boundary spanning*. Lastly, we deduct knowledge from literature on knowledge boundaries and boundary spanning and explore its potential for knowledge sharing within an ecosystem set in a low- and middle-income country.

2.1 Building the Platform Ecosystem

2.1.1 From Generic Enterprise Software to Digital Platforms

Some twenty years ago, the rise of generic software packages to meet the needs of larger heterogeneous user-groups were framed by Bansler & Havn (1996) as the industrialization of software production. This business dynamic enables organizations to buy standard software packages from product owners – also known as vendors – and customize it to fit their respective needs. This way, organizations no longer need to develop their own software for specific needs or use-cases. Rather, organizations need only buy a generic solution, and customize it to fit specific use-cases among several scenarios. This environment can in many ways cut costs and time spent in development, and reduce risks for organizations (Bansler & Erling, 1996; Li, 2019b). Bansler & Havn (1996) predicted that in the years following their research, most IS will take the form of generic software. And seeing the impact vendors of generic software hold in modern enterprise markets, the prediction seems to hold true (Bonina et al., 2021).

Delivering generic software packages as opposed to bespoke software is today a common choice when selling software products to a mass of consumers. Generic software has paved its way into organizations across a spectrum of domains, including health, education, banking, and energy (Li, 2019b; de Reuver et al., 2018). However, further generification in software design, leads to less sensitivity in particularities (Li, 2019b). This would according to Li (2019b) potentially create tension in the relation between being generic and being usable. In other words, in contrast to bespoke systems-design where challenges are fixed to development of custom software for specific use, challenges now, for generic software design, centers at meeting necessities for a heterogenous base. An approach to meet these challenges can for vendors of generic software products be to distribute their products through what is known as *digital platforms*. Strategies related to digital platforms allow vendors to orchestrate contributions from a set of heterogeneous complementors that make up what is known as the platform's *ecosystem* (Wareham et al., 2013). Furthermore, Li (2019b) argues that generic software is increasingly "*[…] designed and branded as software platforms rather than products*". Therefore, adding to the literature stream concerning digital platforms

and platform ecosystems can contribute to further development and innovation of these artefacts.

Related literature provides us with extensive descriptions of digital platforms and its associated concepts. Limiting ourselves to those capturing what is most pertinent, we first draw from Tiwana et al. (2010) as a basis for the physical infrastructure making up the digital platform. They conceptualize software (digital) platforms as an extensible codebase of a software-based system that provides core functionality shared by modules that interoperate with the platform and interfaces that the modules operate through. As this definition captures no more than that of technical attributes, we expand to our understanding from de Reuver et al. (2018). They refer to Tilson et al. (2010) when explaining digital platforms as a "sociotechnical assemblage encompassing the technical elements (of software and hardware) and associated organizational processes and standards". This correlates well with our view on the concept and is of relevance to our study because it highlights the fact that the digital platform not only consists of technical hardware, but the socio-technical aspect of the people and organizations involved with it.

This thesis uses the notion of *innovation platforms* found in Bonina et al. (2021) to build an understanding of digital platforms. Other platform types described in related literature such as the 'transaction platform' is outside the scope of our research, and will therefore be disregarded when mentions of digital platforms follow. On this note, we recognize three important actors found in digital platforms, presented as follows: 1) A platform owner that provides base infrastructure of available resources (i.e., *core software)*; 2); Third-party developers that utilize these resources to complement the core with additional applications (i.e., *complementors*); 3); And users of applications made by the complementors (i.e., *end-users*). The environment in which these actors exist creates what is known as a *platform ecosystem*. Ecosystems are complex in nature and a powerful force in today's software market when governed carefully. The ecosystem plays an important role in the digital platform environment due to its potential for value-creation

via network effects and innovation created by complementors, facilitated through the governance of vendors.

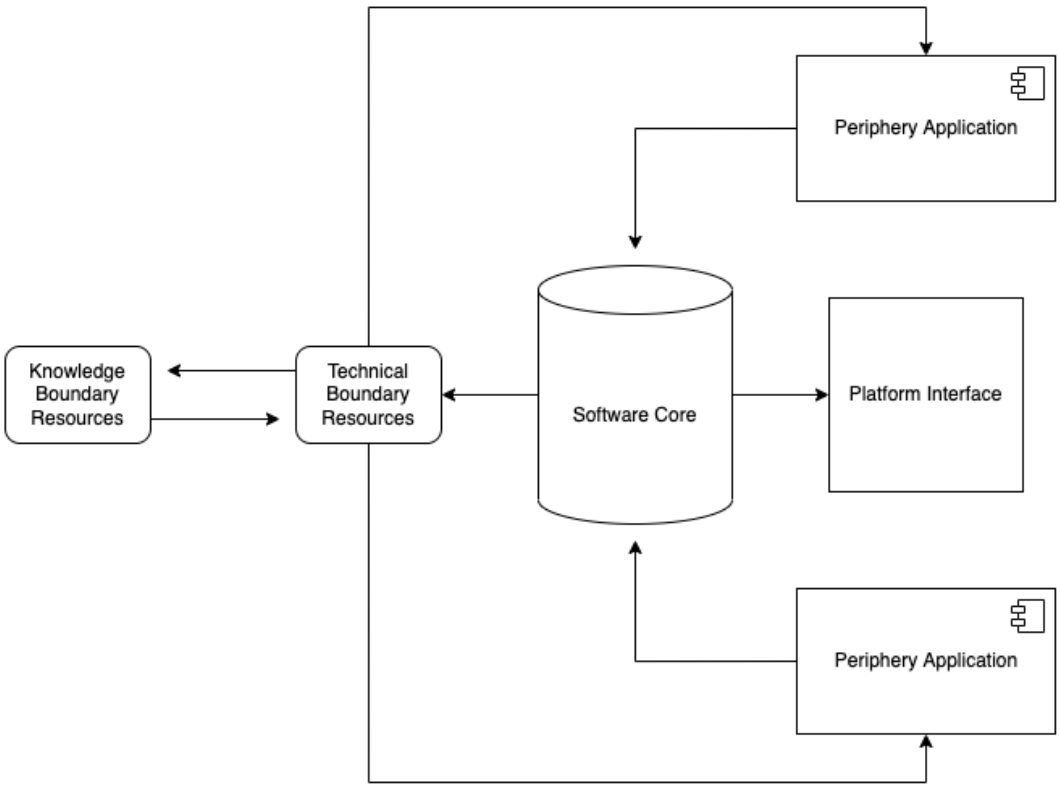


Figure 1 Elements of the digital platform

2.1.2 Digital Platform Ecosystem

Continuing from Tiwana et al., (2010), conceptualizations of a platform ecosystem based purely on technical attributes. They define the ecosystem as a collection of the platform and the modules (i.e., complementary applications) connected to it. Further, Tiwana (2013, p. 5) elaborates on the concept of platform ecosystems, saying it consists of two major elements, a software platform, and complementary applications. Another perspective often taken in researching the platform ecosystem is the business oriented. Through this lens, the platform ecosystem can be understood as "[…] value networks with interwoven value creation processes" (Rickmann et al., 2014). Through a business perspective, Rickmann et al., (2014) conceptualize a platform ecosystem, or as they

name it software ecosystem (SECO), to be the set of complementors, vendor and customers. They proceed to define the SECO as a "set of businesses functioning as a unit and interacting with a shared market for software and services, together with the relationships among them". This is an important notion, as it captures the dynamic in which the organizations come together to achieve a common goal, using the relationships to exchange information, resources, and artifacts (Rickmann et al., 2014). While these conceptualizations explain the technical platform elements, the term *ecosystem* have matured. More recent literature now allots more than the application infrastructure to its definition.

Typical IS literature appears to study platform ecosystems mostly from business and software engineering perspectives. And though learnings about the software, hardware and technical infrastructure building the physical platform are important, more interesting to us, however, are the platform actors and stakeholders, and the dynamic between them and the platform. Therefore, we append some knowledge to the concept of ecosystems, so that our definition is more accurate in relation to the DHIS2 ecosystem. As the previous section presents, the digital platform is built as an assemblage of socio-technical elements (Reuver et al., 2018; Rickmann et al., 2014), naturally then, the ecosystem also shares the socio-technical, and cannot be understood only by its technical infrastructure. In divulging the 'socio-technical', we find that the *technical* represent two main elements: The first constitutes the core software and applications; The second, boundary resources, such as platform API and documentation. The *socio* also represents two main features: The stakeholder organizations such as ISGs and vendor; And other vendor-related resources such as DHIS2 Academy, training and more.

A key feature of the digital platform and the ecosystem is its unique reliance on value-creation and innovation from its complementors. Digital platforms are often built in such a way that system development is carried out by complementors on behalf of the vendor, to satisfy end-users (Ghazawneh & Henfridsson, 2013). This dynamic derives from the modular architecture of the platform, and the arm's-length relationship between vendor and third-parties in the ecosystem (Tiwana et al., 2010; Bonina et al., 2021; Ghazawneh

& Henfridsson, 2013). This links back to the notion that the digital platform is comprised of a generic software package. Gawer (2009) exemplifies this by conceptualizing through platforms like Microsoft, arguing that software found in the core of such systems function as a foundation from which complementors excerpt and build upon. Vendors in digital platform markets have shifted their focus from developing appplications to instead provide generic software packages as base foundations to the complementors. And further, by arm's-length realtion, distribute resources specifically designed to build and implement complementing applications (Ghazawneh & Henfridsson, 2013). The specialized resources are key in the platform environment. Not only do they assists in development of usable applications and implementation of them, they in many ways foster innovation through third-party development when the role of developer shifts from vendor to complementor. These resources are known as boundary resources.

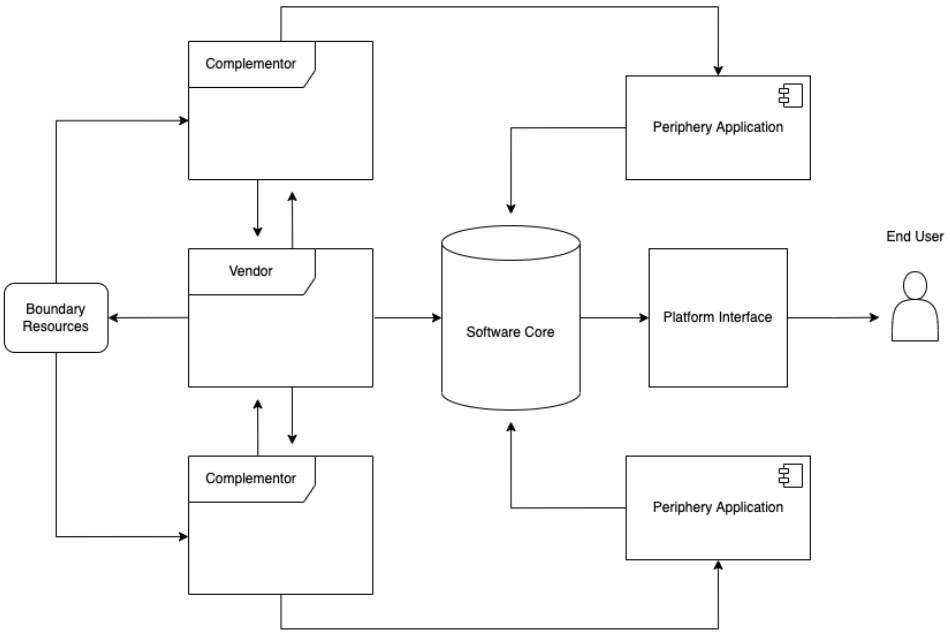


Figure 2 - Elements of the digital platform ecosystem

2.1.4 Boundary Resources

The outcome of platform dynamics found in platform ecosystems often relates to the complementors' relation and vendors' creation of boundary resources. As power and market-share fall at large to a few distributors, agents seeking to utilize these services and stakeholders involved with its diffusion must deal with the paradoxical tension between the increasingly generative and democratic nature of digital technology, and the monopolistic and controlling force of its infrastructure (Eaton et al., 2015). Boundary resources show significant impact in assisting complementors to design software that is usable, allowing vendors to create platforms generative in nature, and ecosystems manageable to govern (Eaton et al., 2015; Ghazawneh & Henfridsson, 2013; Foerderer et al., 2019; Li 2019b). As presented by de Reuver et al. (2018), when drawing from Henfridsson and Bygstad (2013), "*[…] in order to better understand the digital platform dynamics, the core unit of analysis should not be the core of the platform but its boundary resources".* We position theoretical learnings using the same focal point, and build from a widely used definition of boundary resources, explained as "*[…] tools and regulations that serve as the interface for the arm's-length relationship between the platform owner and the application developer"* (Ghazawneh & Henfridsson, 2013). Using this as a foundation, we further expand on it by making a clear cut between two distinct types of boundary resources: Technical boundary resources, and knowledge-based boundary resources.

Common to platforms literature is the importance of boundary resources (BR). Often, when explaining BR herein, the focus lay on its benefits for complementors during development and implementation. By *implementation,* we refer to the actions related to the configuration and customization of software to fit local practices (Li, 2019a). Examples of widely discussed BR in platform literature are platform-specific resources such as APIs and software development kits (SDKs) (Ghazawneh & Henfridsson, 2013; Bonina et.al., 2019; Eaton et al., 2015;), both of which are services, or tools, assisting complementors in implementing or developing software. These types of tools and services are what in this thesis are referred to as technical boundary resources. Furthermore, technical BR often come shaped as code-snippets and *user interface* (UI) components, tailored

specifically to develop custom apps. Development resources are found all over DHIS2's developer documentation, and an example of this is depicted in Image 1. The custom apps are shared for complementors in the ecosystem, and compatible too, due to the standardization applied to the platform. The platform documentation itself is a type of *knowledge* boundary resource, which will be discussed in the next section. Finally, we define technical boundary resources, using theory and concepts from previously discussed literature, and assemble it into: "*Tools and services that arm complementors with capabilities in development and implementation of platform software*".

src/NewProgram.js

```
import { useDataMutation } from '@dhis2/app-runtime'
import { Button } from '@dhis2/ui'

const myMutation = {
    resource: 'programs',
    type: 'create',
    data: {
        name: 'A new Program',
        shortName: 'A new Program',
        programType: 'WITH_REGISTRATION',
    },
}

export const NewProgram = ({ refetch }) => {
    const [mutate, { loading }] = useDataMutation(myMutation)

    const onClick = async () => {
        await mutate()
        refetch()
    }
    return (
        <Button primary small disabled={loading} onClick={onClick}>
            + New
        </Button>
    )
}
```

Image 1 Example showing technical BR in use from DHIS2 developer documentation

2.2 Knowledge Resources to bridge Knowledge Boundaries

As opposed to technical tools and services, vendors also create resources that are purely informative in nature. Literature touches upon such resources, however, they are often described as no more than rules and regulations, and vaguely defined in typical platform research. The very description of BR is in many papers based on the definition found in Ghazawneh & Henfridsson (2013), which states that BR is *software tools and regulations*, or *tools and rules* (Bonina et al., 2021; Rickmann et al., 2014; Eaton et al., 2015; de Reuver et al., 2018). Though the given context is socio-technical when explaining digital platforms, the social part when explaining the coherent BR is often limited to governing techniques and strategies. This excludes an important part of what boundary resources in fact facilitate.

Li (2019b) gives us an introduction to these 'missing' resources when describing what he calls the *design infrastructure*. Design of platform software unfolds on two levels: *Design for use*, and *design for design* (Li, 2019b). 'Design for use' can be explained as sofware not intented to be further customized; 'Design for design' can be explained as base-software intended to be customized before implementation, and other supporting resources designed to assist implementation of software and in further design of software (Li, 2019b). The resources built to support 'design for design' are what form the design infrastrucure described in Li (2019b). Further, resources in the design infrastructure are sectioned into techincal and social. The technical ones correlates well with our previously established definition of technical BR, but more interesting are the social ones. Examples of social resources in the design infrastructure are documentation, learning resources and educational certification programs where "*knowledge specifically relevant to the implementation of the generic software is conveyed to implementation-level designers*" (Li, 2019b).

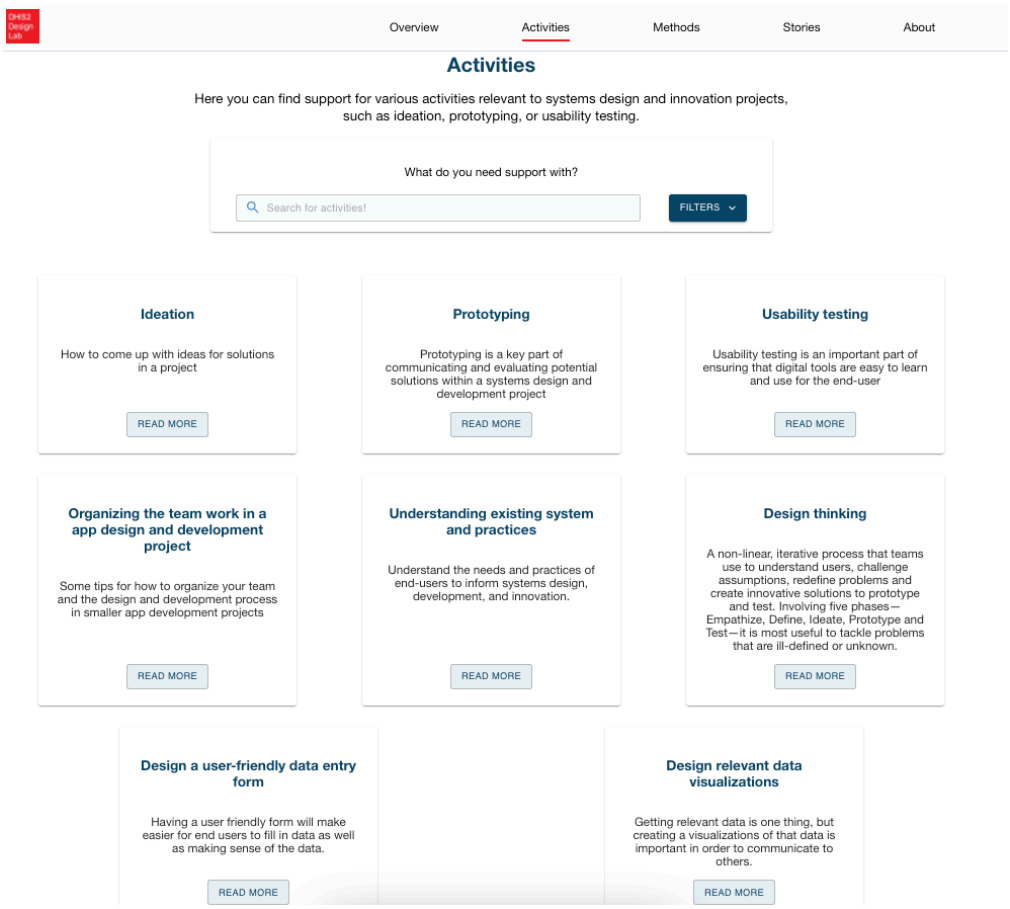


Image 2 Example of Knowledge Boundary Resource. A method tool kit, informing complementors in development practices. Screenshot from: https://methodtoolkit.herokuapp.com/activities

These 'social' type of resources are especially important in fostering complementors' capacity in implementing generic applications, and for them to develop new ones. As Ghazawneh & Henfridsson (2013) discuss, boundary resources are "*[…] Imperative to transfer design capabilities"* to complementors, when the intentions are to shift software development from vendor to complementor. And, as put by Foerderer et al. (2019), the activity of complementary app development is anything but trivial. More so, complementors are in need of knowledge in how to access, combine and extend the platforms functionality so that their capacity for app develpoment is sufficient (Foerderer et al., 2019). We draw from this literature and combine it with descriptions of the social resources found in Li (2019b), and the more commonly recognized rules and regulations, to build what we understand as *knowledge boundary resources.* Included in our conceptualization of knowledge BR are, to mention a few, platform documentation, method tool-kits (see Image 2), platform acadamies and traning resources, and platform

community forums. Also, complementors have the potential to create their own resources, both technical and knowledge-based, also referred to as *self-resourcing* (Eaton et al., 2014; hazawneh & Henfridsson, 2013). Finally, we define knowledge boundary resources based on the preivously discussed literature as "*Informative support-resources created to assist complementors in development and implementation activities".*

Type of Resource	Description	Examples
Technical boundary resource	Tools and services that arm complementors with capabilities in development and implementation of platform software	Platform-API, code-snippets
Knowledge boundary resource	Support resources with intention to inform complementors in development and implementation activities	Documentation, community forums
Non-boundary resource	Resource not related to a specific digital platform	Web-development resources, such as those found at "https://www.w3schools.com/"

Table 1 Type of boundary resources

In this section we build an understanding of knowledge boundaries created in an ecosystem, and the activity of boundary spanning as a method to transfer knowledge between the boundaries to bridge the knowledge gap.

One of the more prominent topics found in recent platform literature is that which discuss the role of complementers to be the main practitioners in producing innovation (Ghazawneh & Henfridsson, 2013; Foerderer et al., 2019). Therefore, as previously mentioned, vendors of generic software has put a sharpened focus on distributing platform specific resources i.e. boundary resources, to ease the process for complementors. Even so, the knowledge in how to use these tools and services can for many complementing organizations be less than trivial (Foerderer et al., 2019). In which cases, the term *knowledge boundaries*, and when not managed appropriately, can be used to explain the knowledge gap created when development knowledge is positioned outside the vendors' boundaries. Simpler put, knowledge boundaries are the differences in platform specific development and implementation knowledge between the different complementors and between them and the vendor within an ecosystem.

Firstly, to identify the internal knowledge boundaries, vendors must engage with the heterogenous nature of their platform ecosystem, so to understand how to best cope with the complex needs of their varying complementors. Platform owners' success are namely linked to their governing practices; More so for those who manage to govern the integration of knowledge across boundaries within the ecosystem (Foerderer et al., 2019). Furthermore, it has been widely accepted that difficult nature of knowledge transfer can play part in explaining why "*[…] a firms effectiveness in integrating knowledge will dinstinguish it from its competitors"* (Foerderer et al., 2019). Antonymous, Foerderer et al. (2019) describes how a platform's failure may be linked to the insufficient governing of its complementors, in which situation, provision of knowledge resources fall short to the complementors, in turn making the negative effect of knowledge boundaries more extreme. An approach to face challenges cause by these 'boundaries', is through *boundary* spanning. The activity is introduced in Hustad & Bechina (2012) and Foerderer et al. (2019), and explained as the activity of combating

the knowledge boundaries created by ecosystem strategies. Boundary spanning is argued to play an important role in influencing complementors' capabilities, as it facilitates for knowledge sharing and knowledge transfer. Hustad & Bechina (2012) discuss boundary spanning, though in a different context than ours. In the context of 'distributed networks of knowledge', or 'DNoK', which they refer to as being a type of community of practice, they discuss what the role of boundary spanning entails in combatting knowledge boundaries found herein. Members in communities of practice (CoP) share, according to Hustad & Bochina (2012), mutual interest and problems, and aim to rely on synergies and and expertise by interacting with each other. The DHIS2 ecosystem can resemble such a community of practice, by the many complementors' desire to extend one another's development and implementation capacity. Also, DHIS2 contains a CoP, though a litle different to the DHIS2 one. Therefore, learnings from Hustad and Bochina's (2012) formulation of the the activitied of and possible challenges with boundary spanning is quite useful for us.

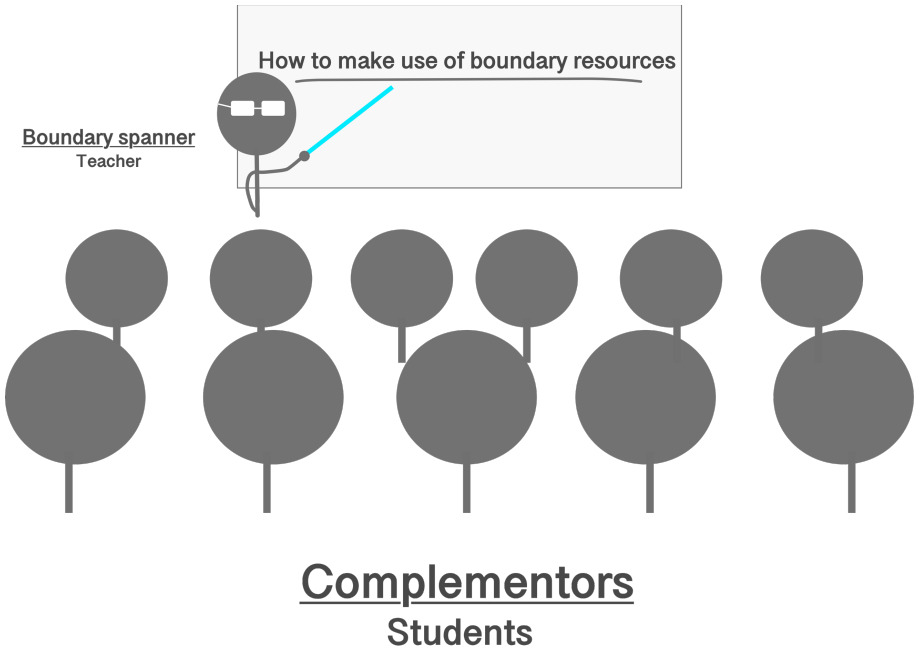


Figure 3 Illustration of Boundary Spanning

2.3 Chapter Summary

Using literature on ecosystems and its varying descriptions and definitions, we can conclude that the essence of the platform ecosystem is defined by its heavy socio-technical nature. The technical parts such as the generic software core and complementing third-party-developed applications are elements needed to fully build and understanding. But the people and organizations within and around are the predominant factor in what creates it. The relationship a complementor has to the vendor and the relationships among complementors are what enables value creation and innovation for transaction and innovation platforms, respectively.

3 Research Approach

This thesis bases its empirical grounding on a one-and-a-half-year-long engaged scholarship following and partaking in the development of a software project for and with DHIS2 stakeholders, HISP UiO, and HISP Rwanda. The software project included online collaboration and a fieldtrip to Rwanda. Additionally, we have complemented our thesis with research on a UiO master's course.

3.1 Research Background

In this subsection we will give a brief introduction to the various organizations and other actors that take part in the continuous research projects on the DHIS2 platform, and more specifically the main actors of this thesis.

3.1.1 HISP

The Health Information Systems Programme (HISP) was an initiative started in South-Africa in 1994 post-apartheid when researchers from the University of Oslo were invited to participate in the Reconstruction and Development Programme (RDP) (Braa & Sahay, 2012). The RDP was a national health programme which provided the population with several primary health care (PHC) benefits (Gizaw, 2014). The goal of RDP was to address the challenges of the deep inequality experienced within the apartheid regime such as lack of PHC availability in underserved communities (Foster, 2004). This was also the birth of the term "information for local action" (Braa & Sahay, 2012) which has since become a central value of the architectural approach of enabling local health facilities to provide information flow from district levels to the national level providing better decision-making enablement.

While working with the RDP, HISP – becoming a team of researchers and health activists, backed with external funding from the Norwegian Agency for Development Cooperation (NORAD) - developed the District Health Information Software version 1(DHIS1) to address the fragmented HIS environment of South-Africa. As explained by Gizaw (2014) The software provided information flow that "[…] allowed for capturing and analyzing monthly statistical public health data at district, regional and provincial level." DHIS1 was considered a success and was by 1998 implemented in two provinces in South-Africa, and by the year 2000 established as the national standard of HMIS (Braa & Sahay, 2012).

The success of the DHIS1 implementation in South-Africa is considered to be the breakthrough for the HISP movement. In later years the DHIS1 was outfaced with version 2, from now on referred to as the DHIS2 which will be addressed in the next section. HISP´s efforts in the RDP, gained world-wide attention and paved the way for implementation projects in large parts of Africa and Asia. To accommodate the attention and demand of digitalization of the health sector in low- and middle-income countries, HISP has since then become a global collaboration of HIS implementation partners which is coordinated by the headquarter in Norway, known as the HISP Centre.

3.1.2 HISP Centre and DHIS2 Core Team

The HISP Centre is the lead and administrative level of the HISP movement located at the University of Oslo. Their vision is to strengthen the health systems in the global south (DHIS2, 2022) to provide low- and middle-income countries with a global public good, available for all countries to download at no cost. The HISP Centre is also responsible for the development of the DHIS2 platform. The developers governing the platform is known as the DHIS2 Core Team. Their responsibility is to provide complementors and the HISP network with technical attributes that makes the platform more accessible, provide DHIS2 training and customer support as well as managing implementation projects of DHIS2 (DHIS2, 2022). An example of their work could be to develop and maintaining API calls which makes it easier for implementation partners to manage data from other technical sources and health systems.

3.1.3 HISP Network and HISP Rwanda

As mentioned, the HISP movement originated from the RDP in South Africa with the engagement of researchers from Norway. However, the programme of developing DHIS2 capacity in other regions and countries have been primarily driven by the network effects from the DHIS1 project's success, but also by the UiO and its students at PhD and Master´s degree level, partnering with ministries of health in low- and middle-income countries (DHIS2, 2022). Some of these students have since been entitled DHIS2 experts and lead HISP groups of DHIS2 developers and implementers in more than 70 countries. One of these HISP groups is HISP Rwanda based in the capital Kigali, which is the DHIS2 implementation partner of interest in this thesis.

Connection "*Implementation Specialist Group*" (ISGs) and Design Lab

3.1.4 DHIS2

District Health Information Software 2 (DHIS2) is a digital innovation platform and the largest one in the world within the health sector. It is an assemblage of software that allows the health sector to integrate various applications, each able to deal with different data sets for different contexts, to one single interface. With a digital platform such as DHIS2, systems integration architecture is an important element in increasing compatibility and efficiency between different nodes in a connected network of HMIS. Without it – therefore fragmented – the network becomes slow and disconnected which impacts data quality, leaving possible gaps of health information. This logic enables DHIS2 information flow between systems, on a single managerial dashboard. Countries can with DHIS2, allow for the sharing of information between different health regions, and personnel ranging from nurses at district levels to the national levels and the Ministries of Health. As a result, this provides countries with a better overview and quality of health information data, which in turn leads to more accurate and transparent decision making.

The basis of DHIS2 can be explained by an innovation platform logic; the architecture is designed with a generic core that enables local innovation. Anyone with internet access can at any time download the most recent version of DHIS2, the source code, as well as required libraries and required third-party products. DHIS2 also comes with a set of bundled apps, developed by the HISP Centre or through their complementors in the South (e.g., HISP Rwanda) available in an 'app store' maintained by the platform owner, the DHIS2 core team. The DHIS2 'app store' is conceptually similar to other app stores from major digital platform actors such as Apple and Google, and some DHIS2 apps are also available on these platforms too. And so, based on the criteria of public goods whereas no user is excluded from using the software and no use of the software interferes with the possibility of use for others, the authors posit that the DHIS2 fits well within this classification. Additionally, the digital nature of DHIS2, meaning that it is flexible and malleable, in addition to being globally available and relevant puts the DHIS2 well in line with the classification of a DGPG (Nicholson et al., 2021).

3.1.5 MoH Rwanda

The Ministry of Health (MoH) is one of the HISP network´s primary user groups. Within most countries, there is a political organ that regulates how health care and health programs should be conducted for its citizens to increase the well-being of the population. The MoH Rwanda has a close collaboration with HISP Rwanda and has together developed multiple DHIS2 applications to provide the country of Rwanda with health services, the latest being the national COVID-19 testing system (DHIS2, 2022).

The role of MoH in this study is important because of their role as the customer of the Report Builder, meaning they have been heavily involved in the ongoing meetings when planning and developing the application delivering user requirements, and reviewing the prototype and final delivery of the MVP.

Through years of collaboration and close connection with the related organizations, HISP UiO and the more recently established DHIS2 design lab group opens for unique possibilities to work through existing close relations between the platform owner (i.e., DHIS2 core team / HISP Centre) and its semi-independent complementary organizations (i.e., HISP groups).

Stakeholder(s)	Description
HISP	A complementor and developer of DHIS2 applications on behalf of customers, often referred to by nationality (e.g., HISP Rwanda). In essence, a consultancy firm implementing DHIS2 software. Role: Implementation partner
HISP Centre	The lead and administrative level of the HISP movement – Could also be perceived as HISP Norway/UiO. Responsible for aligning the DHIS2 community and goals. Role: Vendor
DHIS2 Core Team	A subsection of the HISP Centre. The Core team maintain and configure the technical aspect of the platform core and its components. Providing accessibility and documentation to the HISP community. Role: Vendor
The Design Lab	Researchers located at the HISP Centre. Their purpose is to explore how the DHIS2 platform can increase its adaptability through design and innovation. Usually, the researchers engage in software projects in collaboration with other HISP groups. Role: Vendor
Ministry of Health Rwanda (MoH)	Customer of the Report Builder, and an important stakeholder for HISP Rwanda. Role: Customer

Table 2 List of involved actors3.2 Research methodology

3.2 Research Methodology

Before entering the details of the research of this thesis, we will introduce the origin of our project of interest and the basis for our data collection, The Report Builder. Second, we will introduce our methodological approach. We have chosen to follow the research design model of Myers (2020). The research design model consists of the five components of a research project: *Philosophical assumptions, research method, data collection technique, data analysis approach* and *written record* (Myers, 2020). The research design model has functioned as a roadmap for our research project and will be presented chronologically in the following subsections.

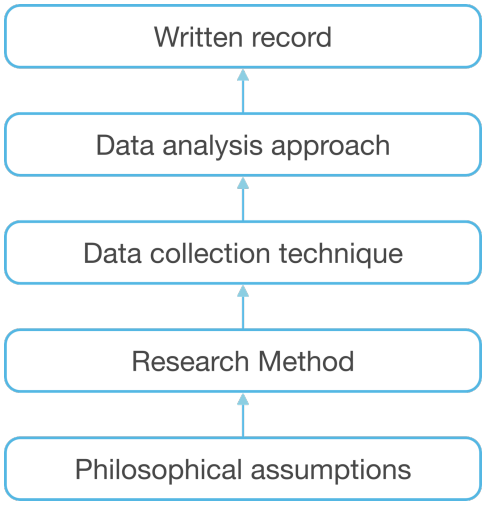


Figure 4 Model of qualitative research design in Qualitative Research in Business & Management (Myers, 2020)

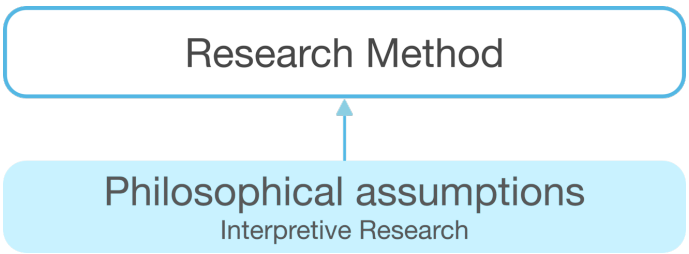
3.2.1 Project origin

The development project presented in this thesis was initiated by the research group '*DHIS2 Design lab'*. The design lab is an ongoing research project part of HISP UiO that explores practices related to software development, design, and implementation of

generic solutions for DHIS2, with the overall goal to "*[…] Strengthen the usability and local relevance of the generic software DHIS2 for end-users, while systematically analysing our activities and results to contribute to research*" (Li, 2019a). This lab, like other '*Design laboratories*', functions not only as an office space that groups researchers together, but much like a research approach. Bødker and Buur (2002) explain this nature as such: "*The design collaboratorium is at the same time a place and a process."* The same nature has been applied to the DHIS2 design lab, being stationed at the University of Oslo, and utilizing engaged scholarship as its core process.

Participants in the lab are split between two classifications: formal and informal. The first type of participant would refer to the PhD-researcher leading the lab, and students researching mostly DHIS2 related topics for their master's thesis'. The second type captures more informal participants, either partaking in portions of the research project or serving as subjects of interest for the researchers in the lab (Li M. , 2019). During the living project we as formal participants collaborated with various informal ones, ranging from core team developers to implementation specialists, to head of implementation in MoH.

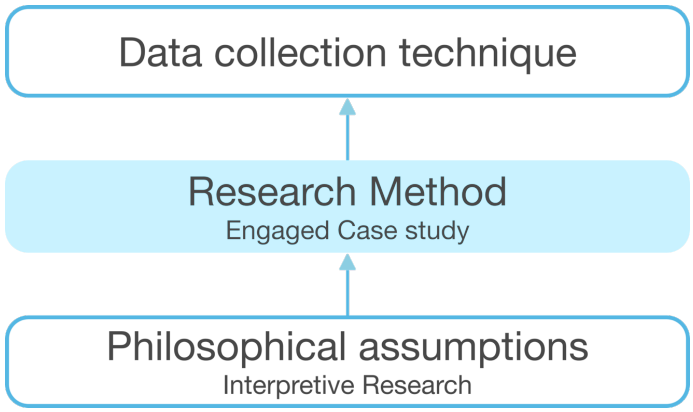
3.2.2 Philosophical Assumption



This thesis has been conducted within the qualitative research paradigm. Considering the epistemological stance which involves the nature of knowledge claims, or how knowledge is perceived, we believe an interpretive approach is fitting for our study of knowledge boundaries due to its socio-technical complexity. This study takes a deep dive into the

knowledge boundaries in the fringes of the DHIS2 Ecosystem, and is a suitable case for an empirical approach that embraces human interpretations and sense-making (Walsham, 1995). Our research has been guided by the assumption that even though the DHIS2 platform has a broad set of BR, it can in many cases stand indifferent to the complementor if its use of them is unknown. As interpretive researchers in this study, we aim to explore how to bridge the knowledge gap created by the heterogeneous nature of the DHIS2 ecosystem.

3.2.3 Engaged Scholarship



As mentioned, the Design Lab consists of both formal and informal participants which are tightly connected to ongoing DHIS2 implementation projects, often in collaboration with ISGs. The Design Lab offers an ideal research environment to study software projects. The lab is exposed to the HISP network as a part of the HISP Centre and DHIS2 Core Team, but also facilitates participation for scholars to gain practical knowledge of their phenomenons of interest to bridge the gap of practice and theory within ES research (Mathiassen & Nielsen, 2008). It was through the Design Lab our study and interest in conducting an engaged scholarship emerged.

Van de Ven illustrates the concept of *engaged scholarship* as "*a participative form of research for obtaining the different perspectives of key stakeholders (researchers, users, clients, sponsors, and practitioners) in studying complex problems* (Van de ven, 2007).

Our interpretation of this is that 'engaged scholarship' offers different perspectives from project participants as it enables researchers to not only observe but also partake in discussions and meetings as a stakeholder, in this case, equal to the other parties of the software project. In our research context, this framework provides us with an environment to gather empirical data through participation as we study the involved stakeholders, (e.g. HISP Rwanda, MoH, DHIS2 Core team, Design Lab) while partaking in an existing use case, the development of the Report Builder.

As we got introduced to the Report Builder project, our main theme of interest was to explore the underlying software process development practices and what challenges would emerge from the Norwegian-Rwandan collaboration. For us, the choice of conducting an engaged scholarship provided us with the flexibility to explore a variety of research methodologies, as it is fitting for qualitative research (Mathiassen, 2017), in order to iteratively evolve our research problem and refine our research approach to contribute to the academic literature of ES research. Li (2021) captures our epistemological research quest perfectly in figure 4, as we analyzed our findings with the most feasible method of inquiry relevant to our research.

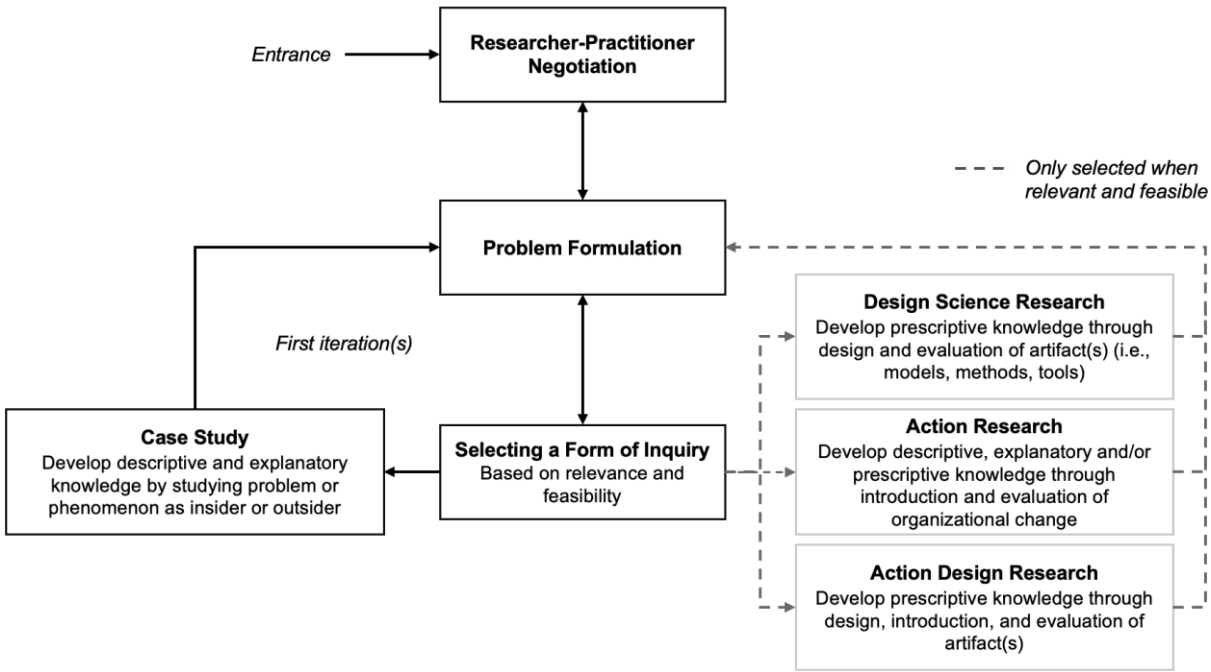


Figure 5 Nature of Engaged Scholarship (Li, 2021)

In the following sections, we will 1) describe how we position our study through the researcher-practitioner negotiation, 2) describe our problem(s) of interest and how they relate to our research question, and 3) elaborate on our selected form of inquiry.

3.2.4 Researcher-practitioner negotiation

Within our engaged scholarship it was essential to define what roles we as researchers would obtain in the collaboration project of the Report Builder (Li M. , 2021). Initially, our position in the project, which will be elaborated on in the next sections, was grounded in contributing to the HISP community as a part of the Design Lab; The initial idea was to propose a SDLC of DHIS2 applications for DHIS2 complementors. As researchers, we would complement the project with knowledge of SDLCs and technical expertise of the DHIS2 platform. However, through our engaged research, we gradually changed positionality as our research question evolved, and direct involvement in the development of the Report Builder accelerated. During this engaged research project, we as members of the Design Lab got interwoven as key enablers in form of technical involvement of the Report Builder, making us “a part” (Van de ven, 2007, p. 288) of the development team from HISP Rwanda of whom we are studying in this thesis.

As participants in the Report Builder project, our research perspective can be defined as *attached insiders*, as our data of inquiry is contextually embedded in the software project, of which we as software developers are key stakeholders (Van de ven, 2007). Our intention with this perspective is to do collaborative basic research (Van de ven, 2007, s. 27) where we as researchers co-produce knowledge with the collaborators of the project

as we describe and explain our RQ through this thesis. As argued by Walsham (2006), the perspectives of the researcher(s) with respect to attached insiders and the contrasting *detached outsider* will vary in this thesis as this case study embraces multiple phases of data inquiry (Walsham, 2006). Because of this, it will be made clear in the thesis when our research perspective and positionality changes

3.2.5 Problem formulation

This thesis´ *original* research question originates from a conversation from the DHIS2 Core team along with observations from the ongoing project planning of the Report Builder. The initial research problem and overall theme involve activities regarding development practices within the DHIS2 community. The underlaying conversation with a representative from the DHIS2 Core Team prior to the planning of the development of the Report Builder app sparked our interest and has since been the building blocks of this thesis.

Q:

"*Do you know how developers in Rwanda structure software development?*

A:

"No, I have little insight to their practices."

Q:

"Do you know where we can find documentation on previous projects?

A:

"No, for me I have little insight to their practices."

We found this conversation interesting on multiple levels. The DHIS2 platform offers access to numerous applications for anyone interested, as well as boundary resources, effectively enabling any user to utilize the platform. However, these applications need to

be documented for users to make use of its technical functionality. Without documentation the applications would require a lot of resources to comprehend, as the code and structure of such an technical artefact need textual documentation, to justify its body of code. To further investigate the problem and develop our research question, we created a set of research objectives that would guide our research process, data collection, and methods of analysis. The research objectives were iteratively subjects to change due to the consecutively cycles of inquiry (Li M. , 2021, s. 10), but also complicated environment of this study. The reasoning of these changes is addressed in chapter 4.

Research Objective	Objective
1	Explore the current development practice of HISP Rwanda.
2	Understand how developers of HISP Rwanda make use of DHIS2 Boundary Resources.

Table 3 Research Objectives

3.2.6 Selection of data inquiry

Being part of the DHIS2 Design Lab opened possibilities to observe and partake in the development of a DHIS2 application rooted in an existing use case. Initially, our intentions were to conduct intervening forms of data inquiry in form of an Action Design Research (ADR) study. The research would focused on uncovering possible development practice shortcomings within the DHIS2-ISG community. Our main contribution would be in the form of an artifact that could serve as methodological guidelines for future DHIS2 software development projects. The artifact would provide the vendor (DHIS2 core team) with a model that could impact the quality of software deliveries from HISP groups, and their test pilot would be the collaboration with HISP Rwanda and the ongoing development of the Report Builder. However, we soon discovered that the feasibility of our research contribution was endangered by the lack of availability and engagement of the developers

in HISP Rwanda. This due to the ongoing pandemic, which created sporadic tasks for the developers in Rwanda, making them need to reprioritize their availability and thus leaving the Report Builder with less urgency. Conducting an ADR would in our scenario require frequent involvement of the developers for us to analyze the impact of the intended artifact. Consequently, we re-evaluated our research approach and focused our interest on the experience of developing the Report Builder.

The shift of form of inquiry did little damage to our research thus far, as we had mainly gathered data from understanding the DHIS2 community and their development practices primarily looking into the practices of HISP Rwanda. We concentrated our research as a case study as we were part of a unique collaboration context and continuously explored and refined our research question to the subject of the matter – how does HISP Rwanda develop applications for DHIS2.

3.2.7 Case Study

The choice of conducting an engaged scholarship left us with the flexibility to adjust our research problem to the method of inquiry to best answer our research question (Li M. , 2021). A case study fitted our pursuit of understanding the development practices of HISP Rwanda perfectly, as it is a descriptive and explanatory method of data inquiry (Mathiassen, 2002), and is acknowledged to be well suited for researching IS (Benbasat et al., 1987). Therefore, posing as an approach well suited to explore the research objectives "*Explore the current development practice of HISP Rwanda*" and "*Understand how developers of HISP Rwanda make use of DHIS2 Boundary Resources"*.

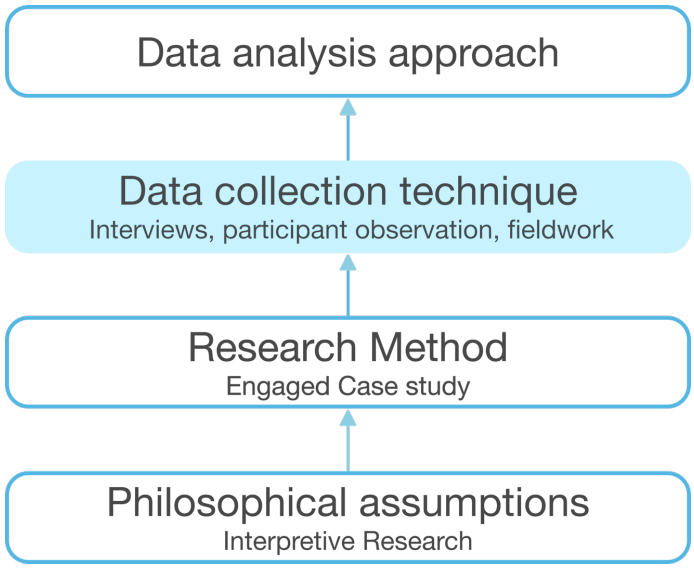
Our connection as attached insiders to the development of the Report Builder provided us with in-depth information to conduct our interpretive research (Walsham, 1995), which is essential to explore and understand how we as researchers can contribute as boundary-spanning agents within this case study. For our thesis, we build upon Stake´s (2005) concept of *instrumental case study.* Even though our study is unique in the context that our engaged scholarship is a pilot project for HISP Rwanda, who has never

collaborated with students from the Design Lab previously, our overall goal is to contribute with generalization of our experience as boundary spanning agents within the DHIS2 community, to shine a light on a potential tendency that other HISP groups might share (Stake, 2005). The case of HISP Rwanda serves as a supporting role to our research question as our findings from this case build an understanding of something that might be going on elsewhere as well.

Concerning our goal to generalize our interpretive research, we make use of two of types of generalization, 1) *drawing of specific implications* and 2) *contribution of rich insight* (Walsham, 1995), to further understand the use of DHIS2 BR in HISP Rwanda as we find both types of generalization valuable for this thesis.

3.3 Methods of data collection

With our methodological structure in place, we needed to plan how we would conduct our data collection for our research. In this section, we will elaborate on our methods of choice and how they have been woven into our engaged case study.



3.3.1 Participant observation and observation from project meetings

During the one-and-a-half years period of the ongoing software project, one of our primary sources of information has been through taking part in meetings with stakeholders from the Report Builder project. The various roles and interest of the stakeholders is presented in *table X.* By *meetings* we refer to zoom-meetings and physical meetings as the same method of taking part of the social activity, considering that this study has taken place during the COVID-19 pandemic.

We have estimated that there has been held 30 meetings during our involvement in the planning of the Report Builder project. In some cases, we would attend as mere spectators in cases where the MoH would lead meetings with 30+ participants, all with different interests in discussing requirements and use cases for the Report Builder. Myers describes observation as "*[…] watching people from the outside"* (Myers, 2020, s. 169). With this, our role was simply to observe the ongoing discussions, without taking any part or physically interacting with the participants. However, in other meetings we, the researchers, were leading the meetings through participatory observation – this was mainly in meetings with few participants, where the Design Lab presented mock-ups and prototypes of a possible solution of the Report Builder. The majority of these meetings involved iterations on the prototype which received feedback from the MoH and HISP Rwanda. We use the definition of participant observation from Myers (2020) "*[…] Participant observation is when you not only observe people doing things, but participate to some extent in these activities as well"* (Myers, 2020, s. 169).

Stakeholders	Roles	Interest	Research perspective
MoH	Customer	Gathering user requirements	Attached-insider
Health workers	End-users	Providing in-depth information of use cases for the Report Builder	Attached-insider
HISP Rwanda	DHIS2 Complementor	Project owner and developer team of the Report Builder	Attached-insider
HISP Tanzania	DHIS2 Complementor	Exploring potential of presented use case for engagement in Tanzania	Detached-outsider
DHIS2 Core Team	DHIS2 Vendor	Vendor representative	Detached-outsider
The Design Lab	Researchers, complementor	- Gathering qualitative data from observations - Advising design- and development strategy of the Report Builder	Attached-insider

Table 4 Table of stakeholders

The true value of this technique of data collection is to observe and attempt to understand the actors in a climate that is natural to the actors of the study. As attached insiders in the Report Builder project, we gained valuable insights from multiple perspectives and relations with multiple stakeholders. By attending, we got exposed to how a DHIS2 ISG planned and organized a software project in terms of requirements handling, scheduling of prototyping, and software deliveries.

3.3.2 Interviews with DHIS2 Network & UiO students

Our second method for gathering qualitative data has been through conducting interviews and engaging in conversations with people of relevance to our study. In this thesis, we have mainly conducted unstructured- and semi-structured types of interviews (Edwards & Holland, 2013).

Unstructured Interviews

As mentioned, our initial research problem originates from a conversation with the DHIS2 Core Team. This conversation can be referred to as an unstructured interview or an *informal interview* (Edwards & Holland, 2013) as we wanted some insight into our software project with HISP Rwanda from the perspective of the vendor role of the DHIS2 Core Team. This form of data collection is a valuable technique as it requires little effort of preparation and can be conducted ad-hoc if needed. In this case, it was a short chat just two stories below our offices in the Design Lab as the offices of the HISP Centre are located in the same building. In this thesis, it is arguably our most used technique of data collection and has proven valuable to gather insight from the DHIS2 community. That being said, it comes with a disadvantage due to its ad-hoc nature. In our research, the informal interviews have rarely been documented on the spot and mostly exist as primary data (Myers, 2020, s. 147) only within our own memory if we did not have time to store them in writing or recordings. We were, however, aware of this weakness and only conducted these conversations when we had time to document our findings shortly after the conversations took place (Edwards & Holland, 2013, s. 31).

Semi-structured interviews

The semi-structured interviews were conducted with an interview guide (Edwards & Holland, 2013, s. 29) as a tool to keep the researcher's questions of interest available. However, the strength of conducting semi-structured interviews lies in its flexibility of adapting to the ongoing conversation with the interviewee. The interviewee could generate answers that the researcher would want to pursue, as the researcher in a semi-structured interview is interested in how the interviewee understands and responds to the theme of interest (Edwards & Holland, 2013, s. 29).

During the ongoing software project, one of the authors of this thesis assisted in the teaching of a UiO master's course (IN5320 - Development in platform ecosystems, 2022). This course is especially interesting in the scope of this thesis, as it involves development of DHIS2-complementary applications. Students partaking in this course underwent an extensive three-month project, during which, experienced the use of DHIS2 technical and knowledge BR. After the final evaluation of the students' respective projects, the author, of which was a TA, conducted a series of semi-structured interviews to capture challenges with these BR.

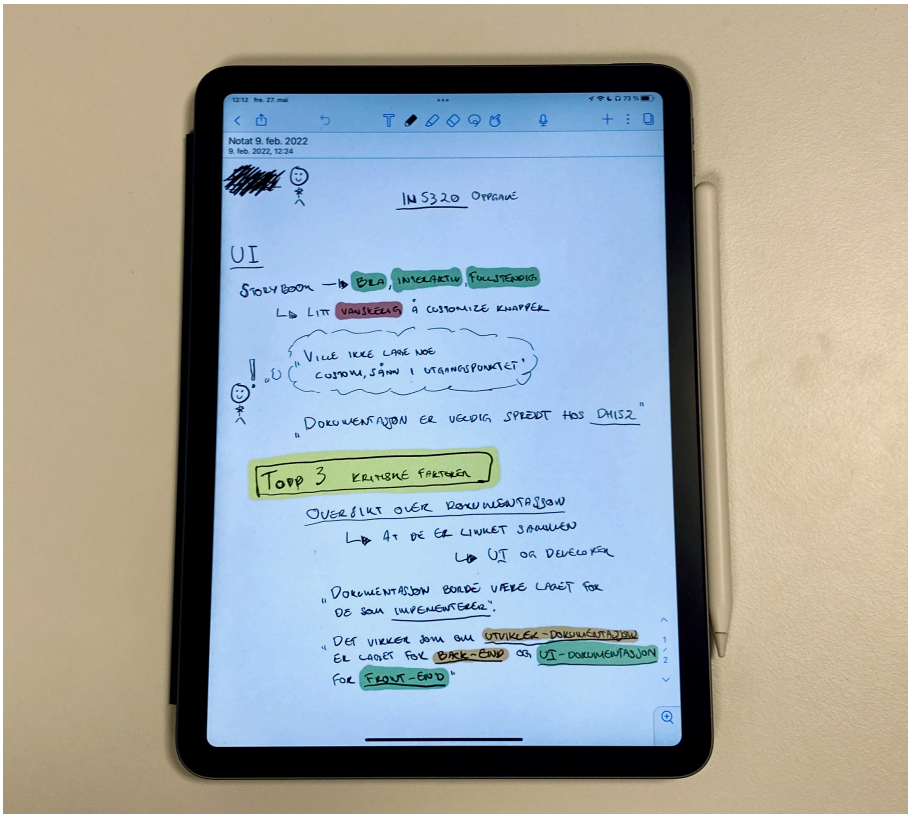


Image 3 Interview Notes

The same interview technique was applied when interviewing developers from the HISP Rwanda team and a project manager from MoH. For our thesis, it was essential to gain information from the developers of HISP Rwanda as our research objective seeks to build an understanding of how developers on the DHIS2 platform experience the boundary

resources that are available, and potential perspectives that would aid our research. As for the project manager, we were interested to get the perspectives of users of the DHIS2 software delivered from HISP Rwanda.

3.3.3 Field Trip

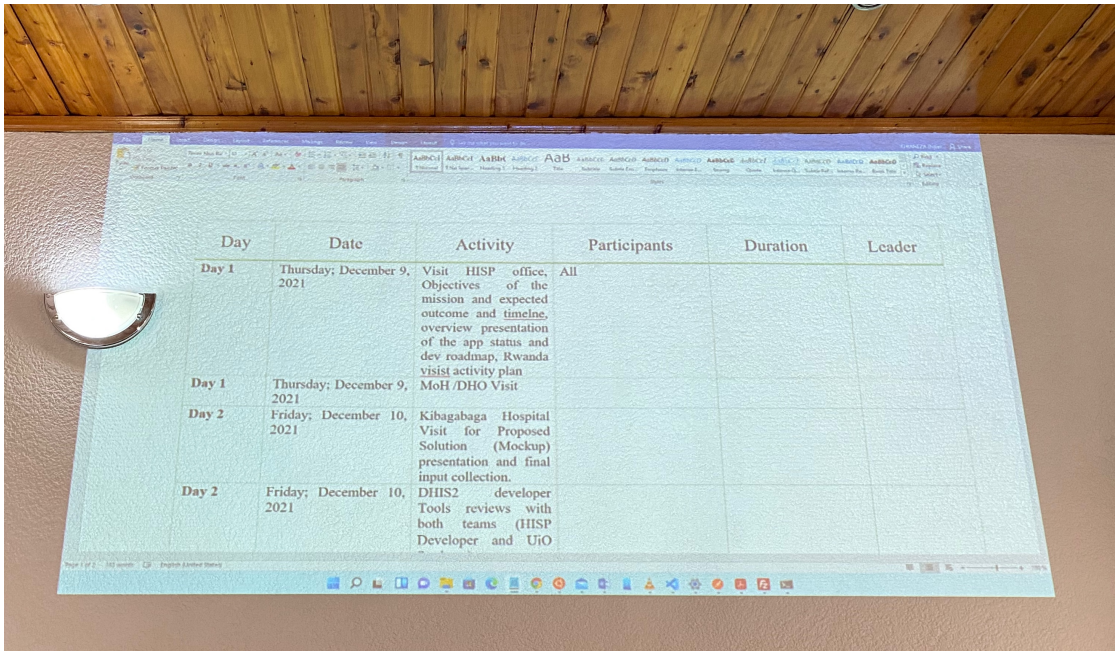
In the closing phases of our scholarship, we, the authors of this thesis along with an additional master´s student from UiO, got time to visit Kigali in December 2021 for two weeks to conduct fieldwork at HISP Rwanda, and to finalize the development of the Report Builder. Fieldwork is as defined by Hughes (2005) "*[…] observation of people in situ; finding them where they are, staying with them in some role which, while acceptable to them, will allow both intimate observation of certain parts of their behavior, and reporting it in ways useful to social science but not harmful to those observed*" (Hughes, 2005, s. 3). In our interpretation of what fieldwork is we add Myers´ (2020) perspective of participant observation, adding the activity of participation to the definition.

The data collection technique of conducting fieldwork also serves as an umbrella term for conducting other methods of data collection, as it does not exclude methods such as conducting interviews or workshops. In contrast, most of these activities happen *during* the fieldwork.

Before arriving in Kigali we thoroughly planned our research objectives of what to partake in as a part of HISP Rwanda´s developer team. As encouraged by Walsham (2006), preparation is key when conducting fieldwork, especially if visiting other countries (Walsham, 2006, s. 23). Traditionally, fieldwork is a method from the social sciences, where the researchers observe cultural phenomena which are completely different from our own in order to understand the beliefs and practices of the country or territory of interest (Myers, 2020, s. 169). In our field trip, our research objective was to explore the development practices of a DHIS2 ISG which included understanding *how it was to be a developer of HISP Rwanda*.

There were mainly three groups of actors involved in our field trip to Kigali. The first and most important actor was HISP Rwanda, who obtained the role of hosting our stay which included providing us with a place to stay and access to their offices to work. The second was MoH, which served as a key informant (Myers, 2020, s. 174), providing us with access to intended end-users of the Report Builder. More importantly, MoH posed as an example of a customer of HISP Rwanda. In other words, our connection with MoH meant that we could observe and engage in the dynamics between HISP Rwanda as a complementing software distributor, and MoH as a customer. The last group of actors was the Design Lab. This group refers to the three master´s students who visited from UiO to partake in the development of the Report Builder.

Seeing that we only had two weeks to visit Kigali, which was heavily regulated by the travel restrictions of international guidelines concerning the COVID-19 pandemic, HISP Rwanda and the MoH created a day-to-day agenda (*see figure X*) for our stay to make the most of our time to work on the Report Builder project. During our stay, it was planned for us to meet various stakeholders ranging from end-users at health facilities to decision-makers at the managerial level at the MoH.



Day	Date	Activity	Participants	Duration	Leader
Day 1	Thursday; December 9, 2021	Visit HISP office, Objectives of the mission and expected outcome and timeline, overview presentation of the app status and dev roadmap, Rwanda visist activity plan	All		
Day 1	Thursday; December 9, 2021	MoH /DHO Visit			
Day 2	Friday; December 10, 2021	Kibagabaga Hospital Visit for Proposed Solution (Mockup) presentation and final input collection.			
Day 2	Friday; December 10, 2021	DHIS2 developer Tools reviews with both teams (HISP Developer and UiO			

Image 4 HISP Rwanda planning our stay

Demos and presentations

During our stay in Kigali, HISP Rwanda facilitated multiple presentations of ongoing projects on the DHIS2 platform *(see figure X)*. This provided our research with insight to how they planned and developed software for their clients. These sessions were presented by consultants with various roles ranging from developers to project managers. In the same fashion, the Design Lab presented the progress on the Report Builder to gather feedback from HISP Rwanda and MoH.

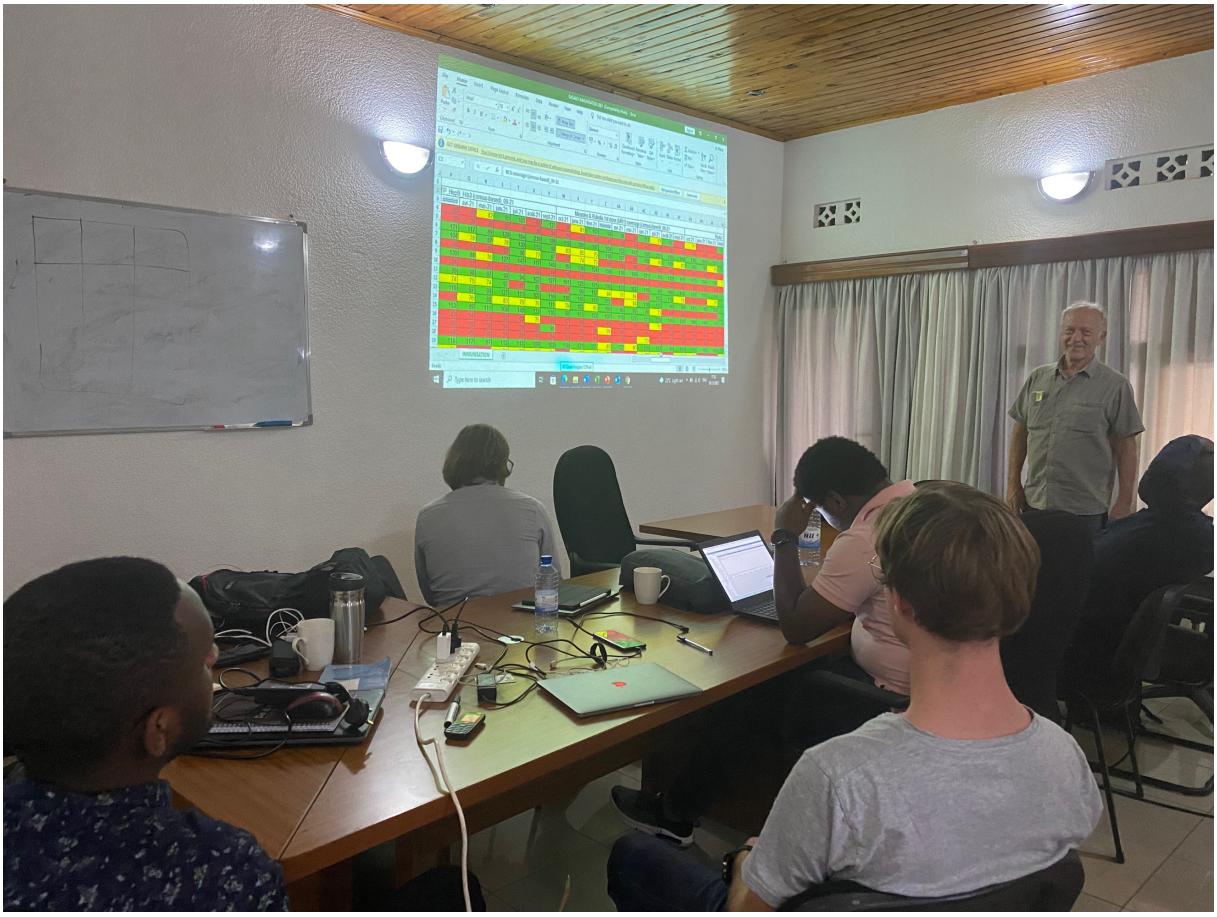


Image 5 Presentation of Tanzania developed Score Card App

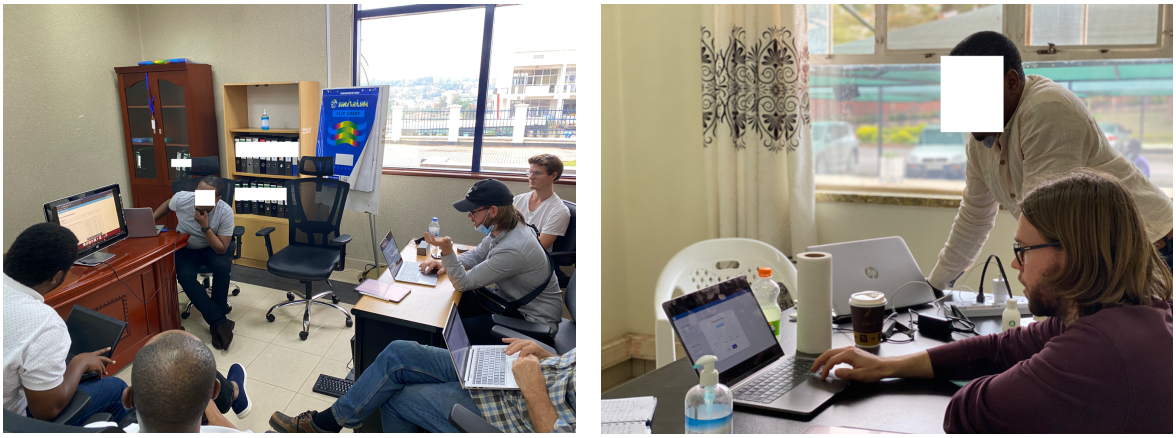


Image 6 Presentation and demo of Report Builder with MoH3.4 Data Analysis

The process of data analysis in this thesis is initially based on a bottom-up approach (Myers, 2020, s. 207). As mentioned, our initial research problem was discovered

through a conversation with the DHIS2 Core Team and is therefore of a data-driven and exploratory nature. However, as our research has progressed, it´s been enriched with theoretical perspectives of IS literature as patterns and possible explanations of phenomena emerged. In the following sections, we will introduce the different approaches of our data analysis, but most importantly the way we had to adapt our analysis as our research took a turn from our findings in Rwanda.

3.4.1 Loose thematic analysis

Considering the complicated evolution of the study and fragmented structure in the living project, mainly due to the sporadic events following the pandemic, and our reliance on observatory data, mostly generated through notetaking; We saw that if by doing our main data-analysis in the end of the project, a large portion of our findings would hold weak links to theory. To account for this, it was necessary for us to continuously re-iterate over our data to understand what theory would pose most fruitful when linking it together.

As an effect of this, we have been needing to approach the activity of data analysis within looser frames, so to open our perspective during analysis. We have drawn from Walsham (2006) as guidance in how to work within such frames, as he too promotes looser frames when conducting data analysis. Our interpretation of his paper is that working within themes is a solid approach, and our main tool to create these themes has been through dialogues and discussions between us as researchers. Consequently, our approach is seemingly inductive. As new data unfolded, so did our theory, and in turn, so too did the scope of our research objectives, and the thesis' contribution. As a result, data analysis has been conducted in two separate fashions; On the one side, data on knowledge resources for use of technical BR has been analyzed using thematic analysis; On the other, data on identifying unknown knowledge boundaries for systems development has been analyzed through continuous discussion of the data within defined themes.

Image 7 Constructing the timeline

As for analyzing what the students experienced when using the knowledge resources in app development, we followed the suggested steps found in Braun & Clark (2006). First step in the data analysis was for us to familiar ourselves with the data. We did this by mapping out the project and points in time of interest (see Image 7), and then going over all our data in succession. Second, we took excerpts from our notes that were interesting and wrote them on to post-it notes, being the initial coding. Third, we searched for pattern by analyzing the coded notes, and paying attention to redundancies in the coded notes. Patterns identified were then revised into initial themes, which we had a few of. Step four was to review the themes and after reviewing the initial themes, step five was to define the most prominent themes. We managed to land on these three themes: *Documentation contains resource; Navigating the documentation for resource; Documentation is missing resource.* Lastly, the outcome of the thematic analysis will be described in the following chapter.

Image 8 Looking for patterns

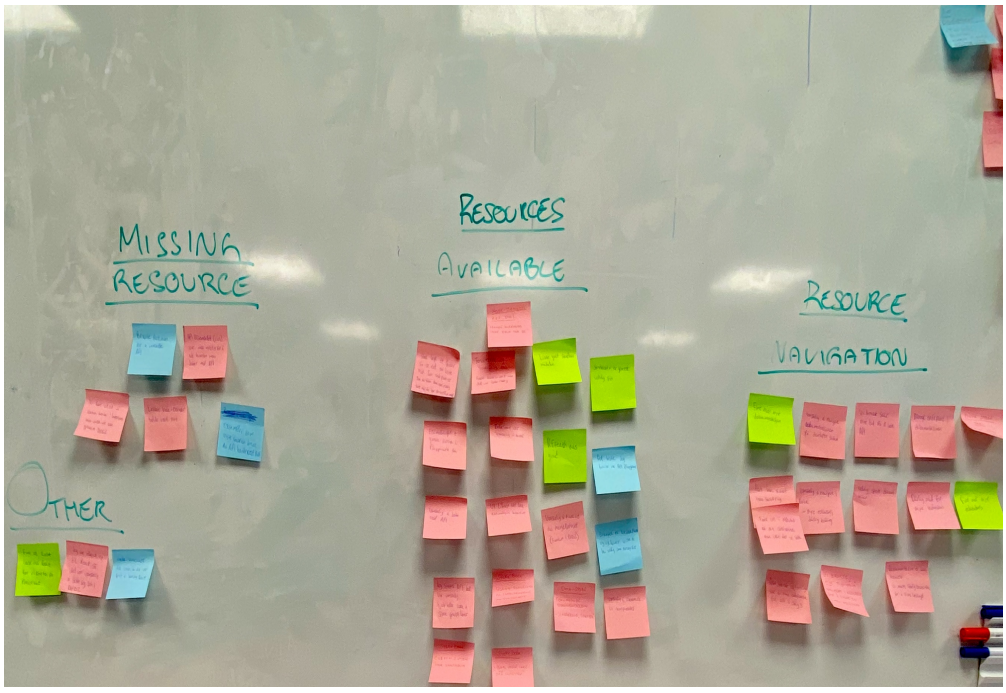


Image 9 Defined themes

3.4.2 Co-analysis

After co-analyzing the meeting-data and experiences from fieldtrip we identified the need to pursuit new research objectives, seeing that our focal point changed. Co-analysis is a rather loose term, describing the activities of discussing and analyzing data and information. Co-analysis happened continuously throughout the project, and some of the more interesting findings were results from such analysis.

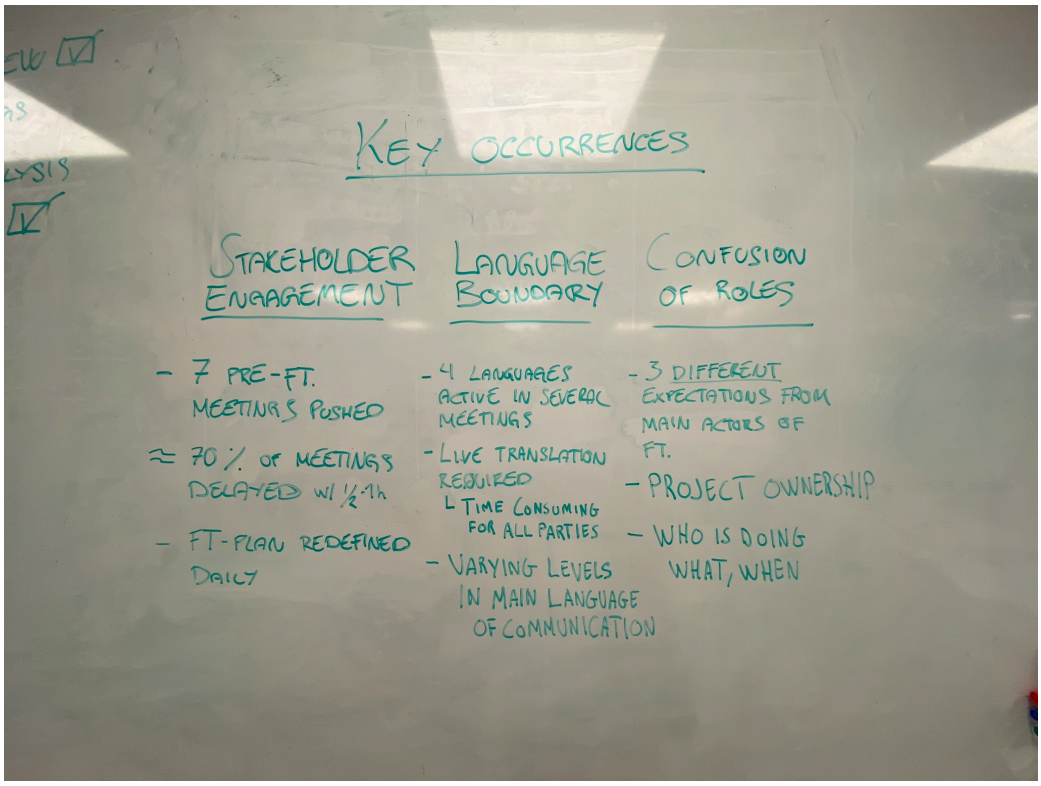


Image 10 The three main themes that emerged from our data analysis

3.5 Chapter summary

This chapter contained the historical background of our research project and its grounding within the HISP community. We have structured our thesis according to the research design model of Myers (2020). The philosophical assumption of our research has its stance within the interpretive research paradigm and the methodology of inquiry leading our research, has been conducted as an instrumental case study in an engaged research project with HISP Rwanda. Guided by the iterative problem-formulation model of Li (2021) we have continuously refined the research problems of this thesis with

several methods of data collection, and thoroughly analyzed our findings through thematic analysis and co-analysis, which will be presented in the following chapter.

4 Findings

This study started out with an exploratory approach to unravel challenges related to the two research objectives described in Chapter 3. As our research unfolded during the continuous and iterative analysis of our data, this engaged case study took a turn due to the unexpected challenges that emerged from our planned fieldwork in Kigali. In this chapter, we will elaborate on our findings and the patterns that emerged when we realized that the three main actors in this thesis, had three completely different ideas of what role the Design Lab served in the Report Builder project.

The next sections are structured as a timeline in the following manner. First, in phase 1, we will introduce our findings from our initial research problems. Phase 1 refer to the data collected and in quick succession analyzed during the first three months of the project. In phase 2, we will present the three perspectives and expectations of the main actors in the fieldwork and how this complicated the development of the Report Builder. Findings in this phase comes from the data collected and analyzed during the six months following

phase 1. Thirdly, the findings from the clash of interests from the fieldwork will be untangled and reassembled to fit a redefined research problem in phase 3. This phase contains data collected and analyzed starting from October 2021 until shortly after the field trip. Lastly, phase 4 presents findings from the interviews conducted with students and the final analysis of all data and findings re-iterated.

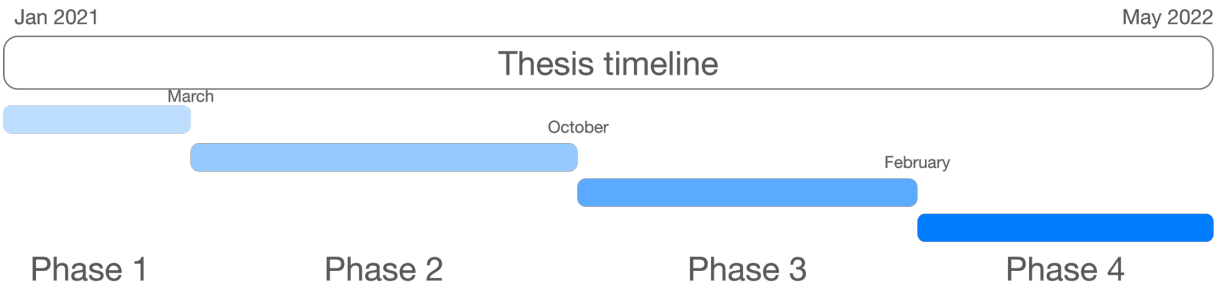


Figure 6 Illustration of our thesis timeline

4.1 Phase 1: App Development Initiative

4.1.1 Project Background

Starting as an online collaborative engagement initiative, the project in phase 1 was fully focused on building a long-awaited application. The origin of the collaboration project tracks back to November 2019. It was a use case provided by the MoH in Rwanda. Health facilities experienced redundant and manual labor related to data entry of medical information to generate health reports. MoH had already implemented modules from the DHIS2 app hub, but the available systems did not reflect the business need for generating health reports from all districts to one consolidated report for the national level. To combine medical data from all districts, health workers would manually generate reports from each district using the DHIS2 to pivot tables (e.g., excel) and merge each district's report together and then re-enter the data to the HMIS. There existed one application possible of generating consolidated reports for multi-levelled and aggregate data, albeit the output when printing this report would not align with the national standard format, and therefore not feasible in practical terms. To accommodate the issue, HISP Rwanda

initiated a collaboration with the Design Lab and DHIS2 Core team to develop a suitable application.

However, due to the pandemic outbreak in early 2020, the project was haltered during about ten months. Seeing that HISP Rwanda needed to respond with ad-hoc implementation deliveries to the MoH, there was little-to-no prioritization left for The Report Builder. The project was eventually re-initiated with an addition to the developer team, now including a group of master's students from UiO Design Lab, onboarded in October 2020, which are the authors of this thesis. The collaboration of combined forces from HISP UiO and HISP Rwanda was to serve as a pilot for such collaboration projects, as this was the first time HISP Rwanda had joined forces with students to develop DHIS2 software. Although an interesting and potent initiative, this collaboration would see some assumed, but also unforeseen challenges.

4.1.2 Lack of documentation on previous software development projects

During the preliminary activities of understanding the project scope and refining the requirements of the application, we conducted a series of unformal discussions with different core-team members and DHIS2 representatives. We learned several useful things from these discussions.

Firstly, representatives from the platform core share a direct communication stream with representatives from HISP Rwanda, one through WhatsApp, and one using slack. In contrast to other platform-facilitated media to communicate through, this stream ensures continuous and direct insight from both partner and vendor on a day-to-day basis. We established a similar communication stream with the developers from HISP Rwanda, so to communicate more freely. Second, when asked if by chance the use of an agile approach when co-developing the report builder would be appropriate, one co-founder of the platform answered: "*Yes very much so, agile is great! We would love to run more development projects using agile approaches."* This sparked an interest in investigating

previous development initiatives, to get a sense of the partner organizations' development practices. As it turns out, when asked if they knew where we could find documentation on previous initiatives, a core team member said *"Sorry, I don't really have any leads on where you can find documentation on previous projects, actually, it's like a black hole for us here"*. Nevertheless, we were determined to improve our understanding in how to best structure our development process and so we asked a product manager if they knew about partners' development practices and was given the response: "*We have little to no insight into how they actually structure app development"*. The response was perhaps not what we anticipated, however, quite useful.

These findings indicated that there were possibilities for us to draw from existing development processes and build an adapted model for use during the development of the applications. This indicates the first shift in our research objective and the first indication of a knowledge boundary.

4.2 Phase 2: Development practices and ADR?

Phase 1 established an understanding for us as researchers about the stakeholders of the Report Builder project. As mentioned, this study is based on an exploratory data-driven approach, and it was in phase 1 that our research uncovered the potential to investigate the development practices of ISGs of DHIS2 applications, where HISP Rwanda served as a key research subject due to our ongoing development project. At this point we realized that our findings suggested that there were no standardized development practices in place to follow for the Report Builder project, and we decided to act on this discovery. Consequently, the contents of phase 2 describes the findings from our role now as boundary-spanning agents, in an attempt to apply an adapted model with which intentions to structure a software development project.

4.2.1 Ideating the development model

With intentions to create an adapted model and apply this artifact to the development process shared by developers from UiO i.e., us authors and the developers from HISP

Rwanda, we now found ourselves within the deeply engaged method ADR. Our research now had the following research objectives: What literature do we use and how do we adapt it to create a viable development process model; And how can we as boundary spanners contribute to HISP Rwanda's development practices. To prematurely spoil the outcome of these objectives: We couldn't. Forthcoming in this section, two main challenges will explain why our intended action design research failed.

We were lucky enough to see phase 2 of the Report Builder project being subject not only to our thesis, but it also served as a key objective in a conference paper, which we helped to write and present. The other authors of the paper had monitored the evolution of the Report Builder initiative previous to our onboarding, and now, with us in place, followed the progress being made during this phase and portion of the coming one. We found a great amount of relevant research already conducted for us to familiarize ourselves with, and so, the study for our paper assisted in building an understanding of the impact the Report Builder would have. Furthermore, the authors, with help from the founder of the design lab, started an initiative to use the master's course presented in section 3.3.2 to test and analyse the intended process model. We were given access to the course curriculum and were allowed to assist in developing alternative assignments for students to choose to follow during their semester project. With this level of engagement and available resources, how could we not succeed with our intended artefact?

DHIS2 Reporting Form Builder MEETING II (MOH, HISP – RW~UIO)

KEY ACTION POINTS (Tuesday, March 9, 2021)

Action	Responsible Personnel	Timeline
Prepare key activities for the DHIS2 Reporting Form Builder App and expected timeline with UIO Master student representative.	[redacted], Hisp-Rw (Backed by Mikael Olsen Rodvelt -UIO)	Should have an update in the next meeting scheduled Tuesday, March 16th ,2021.
UIO Master students' team to share Mockup or development tools that can be used.	Magnus Li to coordinate/ Assign a representative	Agreed tools to be agreed upon, once Mock-up stage is complete. Any other discoveries shall be added on Tuesday, March 16th, 2021 scheduled meeting.
Work on a PowerPoint 'Mock-Up' for the DHIS2 App suggestion.	[redacted] - Hisp-Rw to work hand in hand with the selected team of developers.	Deadline to be communicated on Tuesday, March 16th, 2021 scheduled meeting.
Coordination of documentation of the continued steps being taken.	[redacted], Hisp – Rw to work with an assigned UIO Master's Student.	Update on status, and what is to be expected of the team as assigned, On Tuesday, March 16th, 2021 scheduled meeting and the continued progress.

Figure 7 Action plan from a meeting during phase 2

4.2.2 ADR: Action Design Roadblock

First off, as we researched and studied the use of agile approaches, for so to build a provisional agile method, the level of *stakeholder engagement* indicated that the feasibility of applying the model to our software development process would decrease. The first indication came after the agreement of a bi-weekly meeting schedule to serve as the first implementation of a more agile approach, where every other meeting would serve as a presentation of progress with feedback, and the other would be the start of another iteration. However, throughout the duration of phase 2, several meetings were heavily delayed and often times pushed despite the agreement on a bi-weekly standard for all relevant stakeholders to partake in. Additionally, a second indication of this shortcoming arose due to the ongoing pandemic, when the Rwandan partner organization, and their product owner, the Rwandan MoH, had at to shift their focus to other, more pressing matters; And, despite how understandable this prioritization challenge was, it would not be the last time such engagement deviations occurred.

Further, and more crucial to the planned ADR project, was for the developers from HISP Rwanda to claim ownership of the application. During phase 2, a consistent lack in ownership of the application started to build. We students found ourselves with a continuous feeling that the responsibility to keep progressing the project laid in our hands. This was an increasingly challenging situation, as several representatives from UiO stated:

"*It is vital that there exists some form of ownership of the application from the Rwandan side. It can be problematic for future improvements and maintenance of the application if they do not contribute enough to the development of it.*"

This in retrospect marked the first indications in what we refer to as *confusion of roles.* And in the following phases, the challenges accompanying confusion of roles would become more prominent. An example of this can be shown in figure 6, where the students were assigned to select which tool to be used to design the prototype, meanwhile a HISP

Rwanda representative were to assist in the development of the initial mock-up. The result was that the students were left with both tasks.

Co-analysing the experiences so far in the project, we determined that we were amid major complications for the feasibility of the ADR project. On the one hand, we were experiencing a challenging lack in stakeholder engagement. However, on the other hand, we might have been too naïve in our assumptions that we could simply 'enforce' a 'Scandinavian' approach to the development process. No matter the reason, it was contesting the feasibility of our intended research. Additionally, we were concerned about the dynamics of the designated roles among the project participants, and the ownership of the application. At this point in time, there could have been three reasons for this: Firstly, the representatives from HISP Rwanda were not being up-front about their intended roles in the development of the application; Second, there was a major communication error in who is doing what during the development of the application; Lastly, we as students were not being clear about our intentions for this project. Again, whichever of these were the case, and perhaps they all were, it was creating conflicts with our intended research. As we discovered during our final phase, and which will be elaborated on further, the latter challenge of 'who was doing what' was most likely due to the fact that the Rwandan participants were inexperienced with prototyping, and the programming language we were to develop in.

In summary, two main challenges – stakeholder engagement and confusion of roles – posed as hinders in effectively applying a well-defined and agile method to the development process. The challenges eventually got the better of our intended ADR as we saw that the effects of our artefact would be extremely difficult to measure. However, from the findings about the mentioned challenges, sprouted new potential for an interesting research objective. The goal now was to uncover the existing development practices used for developers situated in HISP Rwanda, for so to contribute with insight into how one should go about designing a software development model for local use.

4.3 Phase 3: A new approach and the field trip to Kigali.

The pandemic had heavily influenced our work in the Report Builder thus far. At this stage in the project, HISP Rwanda was responsible for the development of the COVID-19 vaccination program for the local MoH. This left the Report Builder project with little input from both HISP Rwanda and MoH during phase 2 and 3. Our main method of communication, zoom meetings, was constantly delayed as HISP Rwanda and MoH had little time to prioritize our project. From the Design lab´s perspective, we found ourselves prototyping (see Fig x,x) a use case we were yet to fully understand, and with little-to-no access to the end-users of the application.

Concurrently, we had to re-evaluate the contribution. As we had previously realized in phase 2, the intended intervening form of research contribution was unrealistic. More precisely, due to the lack of access to our main research subjects. Our data now suggested that we could rephrase our study as an engaged case study, which has been described in Chapter 3.2.7. By doing so we saw the potential of exploring the development practice of the Report Builder as a descriptive thesis that could explore the challenges we embarked on during the development. With this approach, we formulated a new research problem: "*Explore the current development practice of HISP Rwanda*" with the intention to promote future collaborative projects for the Design Lab with ISGs.

Hindsight indicated that It would be difficult to explore this research objective through the means of digital communication tools. Therefore, when in November 2021, Norway re-opened the possibility for international travel, we as researchers saw the opportunity to bring our objectives down to a more realistic working environment, through an ad-hoc field trip to Rwanda, Kigali. The following section describes our findings from our fieldwork and the unexpected challenges that shortly followed.

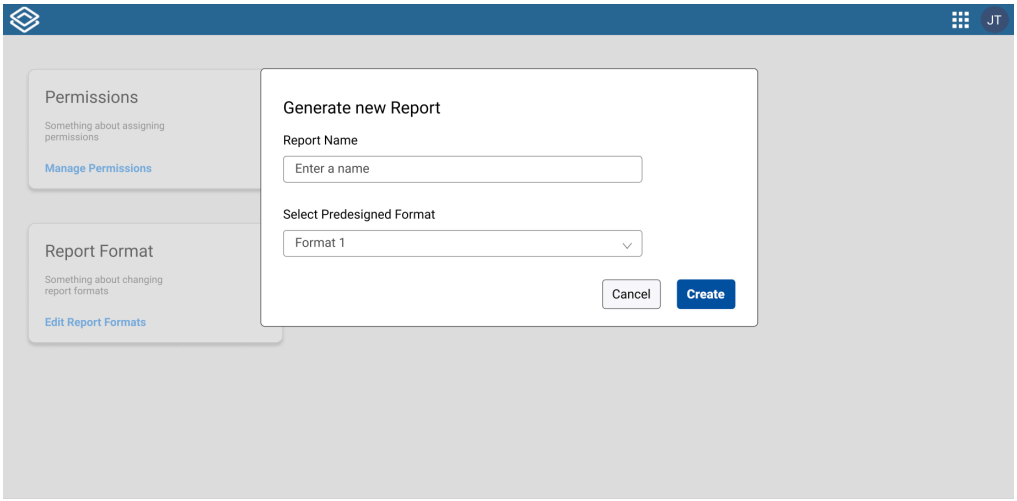


Figure 8 Screenshot of prototype 1.0

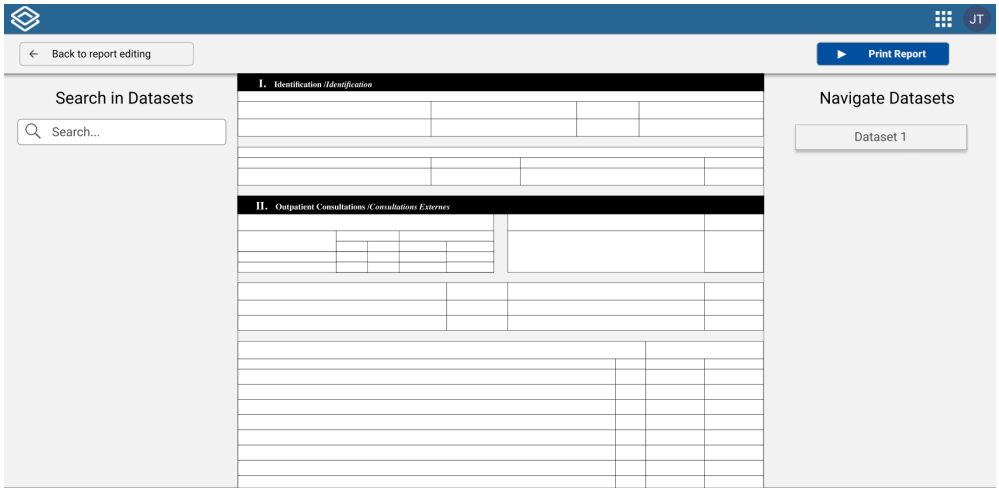


Figure 9 Screenshot of prototype 1.0

4.3.1 Fieldwork: The perspective from the Design Lab

Before the fieldtrip we had conducted a series of meetings with HISP Rwanda, MoH, and relevant stakeholders to discuss the progress so far, the scope of the fieldwork, and the intentions we had for our visit. HISP Rwanda assured us that they would have a plan for our stay, which we agreed was a reasonable approach. We did not, however, see the details of the plan until we arrived at the local offices. This minor oversight would in turn hold further complications for our intended research. Continuing, our main priority

following our arrival was to actively engage and observe the development of the Report Builder through co-development with the partner organization. Our intentions were for this fieldtrip to serve our thesis and contribution-to-be with findings from which we could evaluate the experiences of merging different development practices together and the potential challenges that could emerge from these activities. Surprisingly, when presented with the anticipated, detailed plan, of the activities for our stay, HISP Rwanda seemingly did not share the same perspective as us, and nor did we theirs.

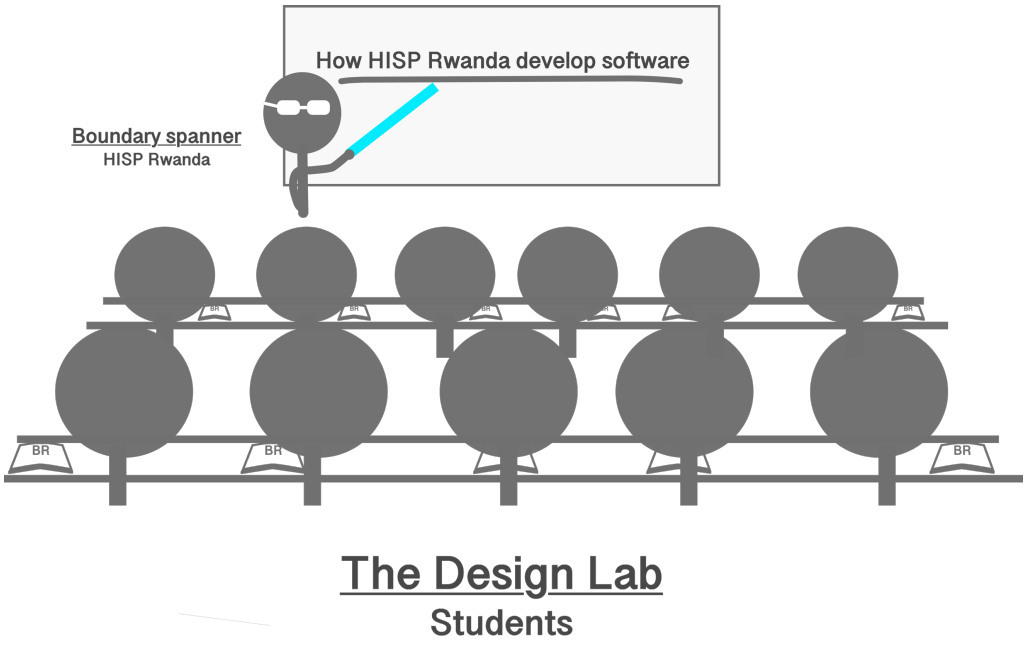


Figure 10 Illustration of The Design Lab´s perspective of roles in the Report Builder project

4.3.2 Fieldwork: The perspective of HISP Rwanda

HISP Rwanda was under the assumption that we students from the Design Lab was onboarded to the Report Builder project to transfer technical app development knowledge; More specifically, the JavaScript library React (Meta Platforms Inc, 2022). *React is the main programming language with which we programmed the application*. Their planned activities for the field trip were for us to function as knowledge-boundary spanners that would serve the HISP office with capacity building in React capabilities. Assumably, because their current developers had little experience with and knowledge of this technical domain. To enable such boundary spanning, the HISP office structured

a day-to-day plan for our stay with specific activities prioritizing the development of the Report Builder. And yet again, with another unforeseen role, their plan included workshops where the Design Lab was responsible for teaching React development knowledge. The presented plan conflicting with our research objectives, and created two major challenges for our fieldwork, as we only had twelve days to conduct our in-field research. The challenges are presented as follows:

1. The developers of HISP Rwanda could not assist with React development, leaving the Report Builder with fewer developers, and the main expertise left in the hands of the design lab. This is an issue relating both to the confusion of roles and stakeholder engagement.

2. We had not prepared for boundary spanning of React development knowledge. The challenge was not a matter of capacity, seeing that two of the Design Lab members were TAs in the above-mentioned master's course. Rather, the challenge was to juggle the requested workshop activities, while at the same time making sure we were able to complete the application. This was an issue relating to the challenges with miscommunication and confusion of roles.

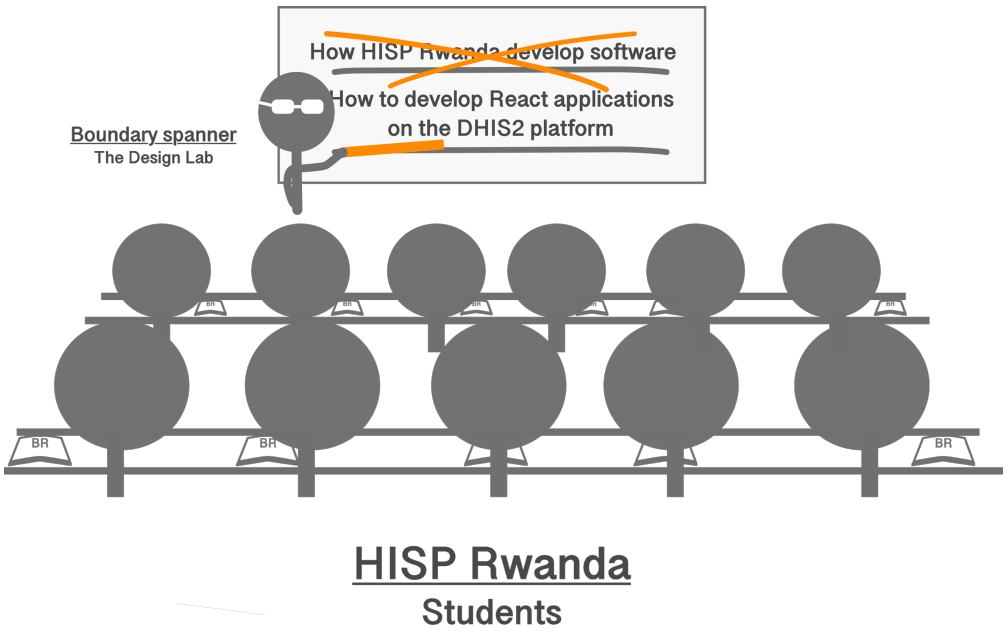


Figure 11 Illustration of HISP Rwanda's perspective of roles in the Report Builder project

Because the developers of HISP Rwanda had little experience with the technical resources to be used in the development, we were left with a role far beyond the initial scope. Consequently, we had to re-prioritize our time and resources into the development of the Report Builder, leaving little room for us to learn about our actual research objective. In effect, HISP Rwanda´s agenda for our stay placed us in a new role within the Report Builder project. We were no longer serving as co-developers from the Design Lab. We were functioning as HISP Rwanda developers whose priority was to deliver the Report builder project within twelve days - eight excluding the weekends. Even though our work remained the same in terms of application development, it limited the empirical research evidence for our study of co-development. The reoccurring theme of *confusion of roles* emerged, once again.

Now, the most fruitful approach of collaboration would be to follow HISP Rwanda´s field trip plan, although without capacity to prioritize the boundary-spanning workshops. HISP Rwanda had planned thoroughly (see figure X) for the development process of the Report Builder, and we agreed to develop the minimal viable product (MVP) of the Report Builder, so to for them to finalize at a later stage, with respect to assuring HISP Rwanda claiming ownership of the project. Probably unsurprising now, as we got ready to start the development, a new problem emerged.

4.3.3 Fieldwork: The Prototype That Was Lost in Translation

The prototype we had created during phase 2 through 3 (prototype 1.0), did not fulfil the requirements MoH-and-HISP Rwanda had thought out, and did not solve the current issue of the use case, when presented on day one at HISP Rwanda's offices. This, despite continuous iterations of feedback from which we progressively tuned and altered the prototype. As mentioned at the start of this section, the project had previously 'suffered' from a shortage of critique from stakeholders during discussions in online meetings. Ironically, what might have been naively perceived by us students as a unified agreement from the stakeholders on the state of the prototype, seeing the lack in critique it received, was in reality an issue of challenges with communication. The lack of feedback, or at least the lack of constructive criticism, has been a theme of reoccurrence.

We have described this theme of findings as *challenges with communication.* The withholding of constructiveness from HISP Rwanda, MoH, and other stakeholders, labelled by us as 'miscommunication' was from retrospective co-analysis quite possibly more a case of eagerness to get started on the development. A constant push from stakeholders to start producing an MVP, with our focus on generating useful feedback from prototypes might have resulted in the Rwandan counterparts tiring to our 'Scandinavian' approach. Nevertheless, as the field trip plan suggested that we were to test Prototype 1.0 in a few days, we needed to adjust accordingly. An iteration of a new prototype was then quickly initiated, and one discovery from our fieldwork, which may be to no surprise, is that the value of having physical interaction while exchanging ideas is quite significant. The prototype below (prototype 2.0) was compiled already after the first three days, worked on over the weekend. In contrast, prototype 1.0, roamed free of criticism for nearly six months, being the victim of the server engagement challenges due covid, and showing the negative forces of the challenges with communication.

It's important for us to note, that the lack in stakeholder engagement applies to us as researchers too. We also share the responsibility in ensuring that what is intended to be gained from such a collaboration finds place.

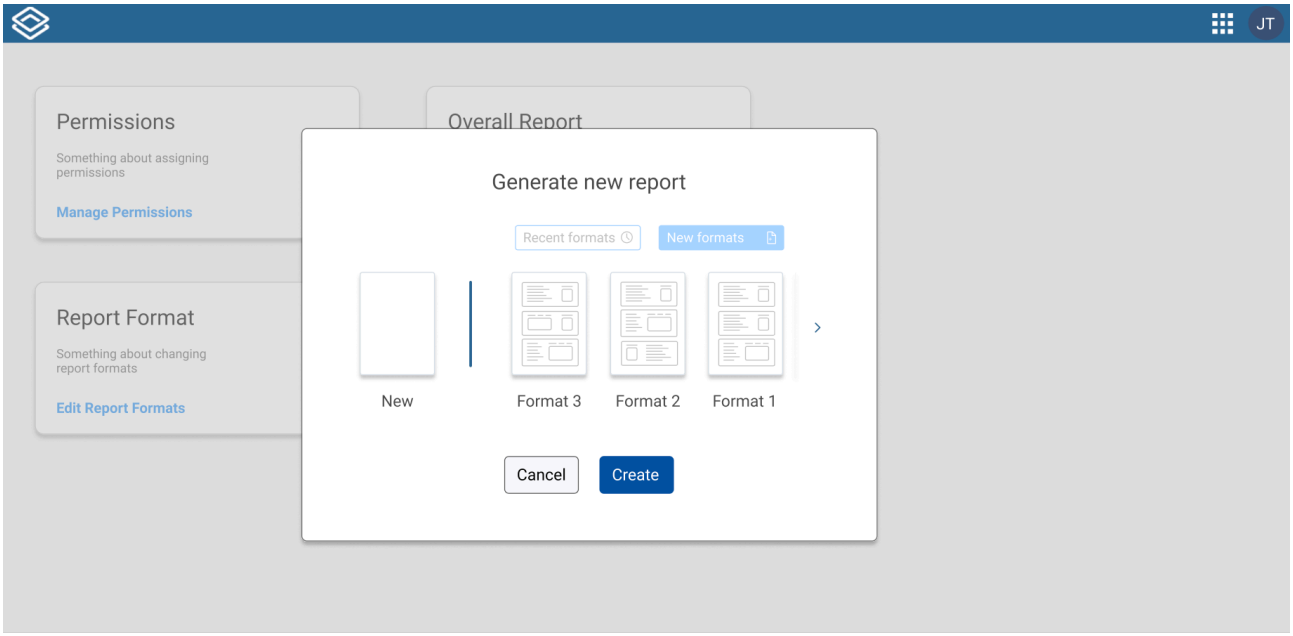


Figure 12 Screenshot of prototype 2.0

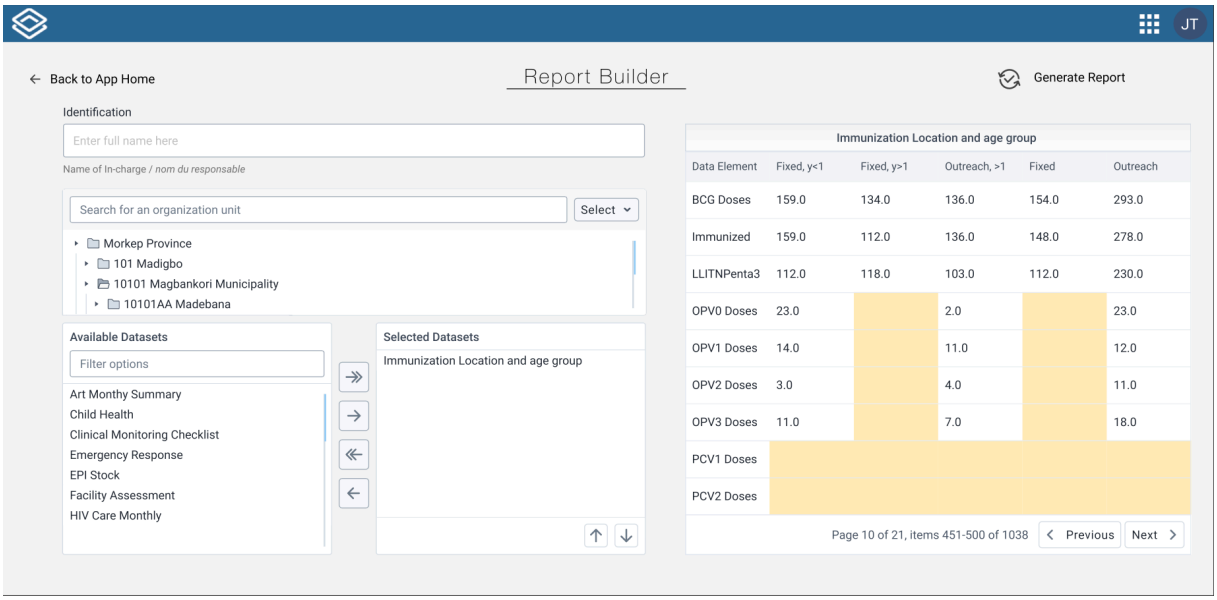


Figure 13 Screenshot of prototype 2.0

4.3.4 Fieldwork: The hectic field trip agenda

Within the field trip plan that HISP Rwanda presented to us on the first day, we had an upcoming demo of our prototype. However, this meeting was abandoned as the test subjects were unable to attend our demonstration of the proposed prototype. This was an incident that occurred frequently. The figure below (figure 24) is a visual representation

from field notes of the planned activities from the field trip plan and how the events got re-prioritized during our stay.

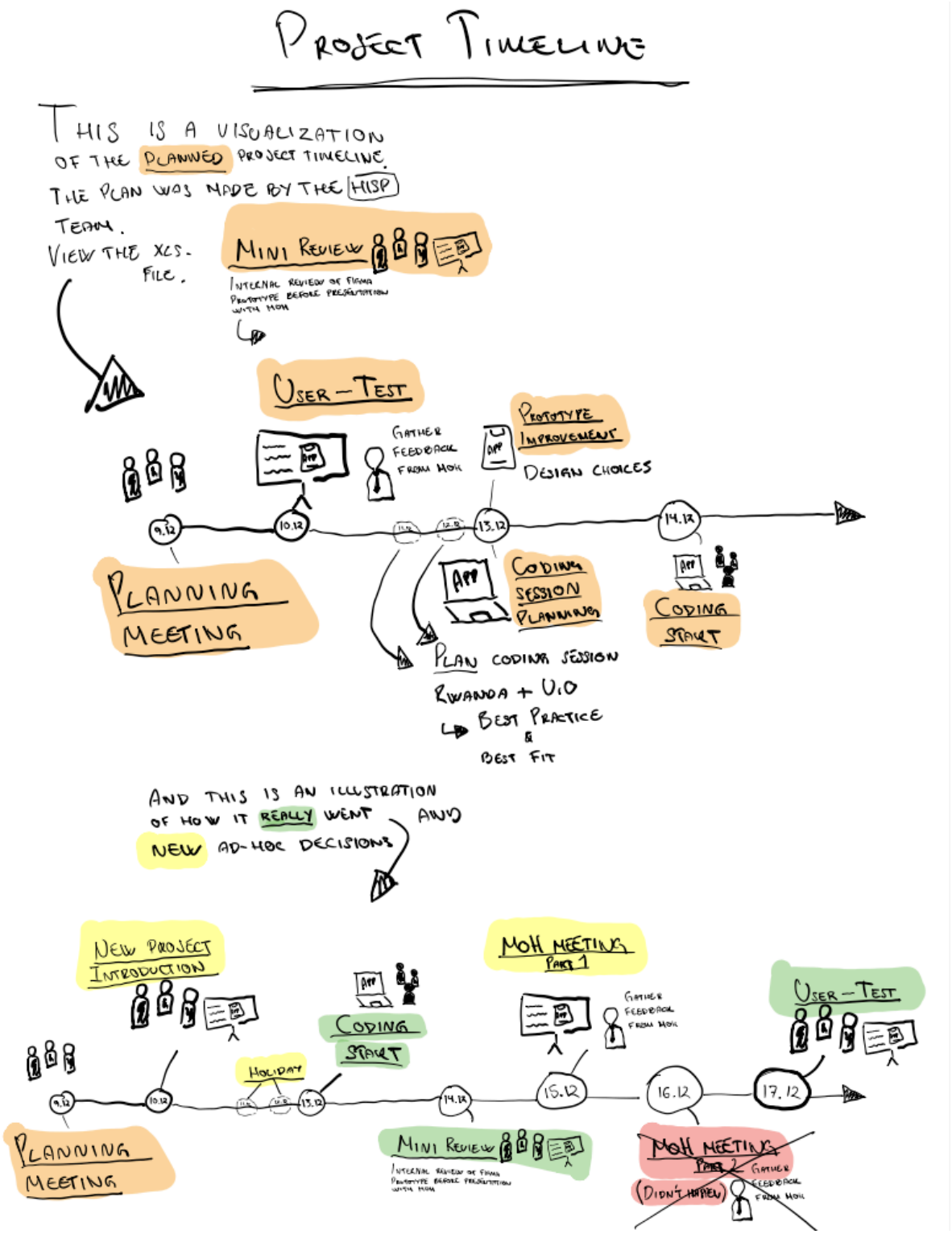


Figure 14 Illustration from a field note of the field trip agenda

The details of the events presented in figure X are not of importance. What is, however, is how the figure illustrates the flexible nature of the project timeline as *all* planned activities (orange colour) were postponed, rushed to an earlier date, or completely abandoned.

Even though our demo of the prototype was postponed, we had to start development of the Report Builder MVP in order to finalize the project on time. During the ongoing development of the Report Builder, we got time to present our MVP to the MoH on two occasions. The final demo was held on the offices of the MoH for fourteen test subjects.

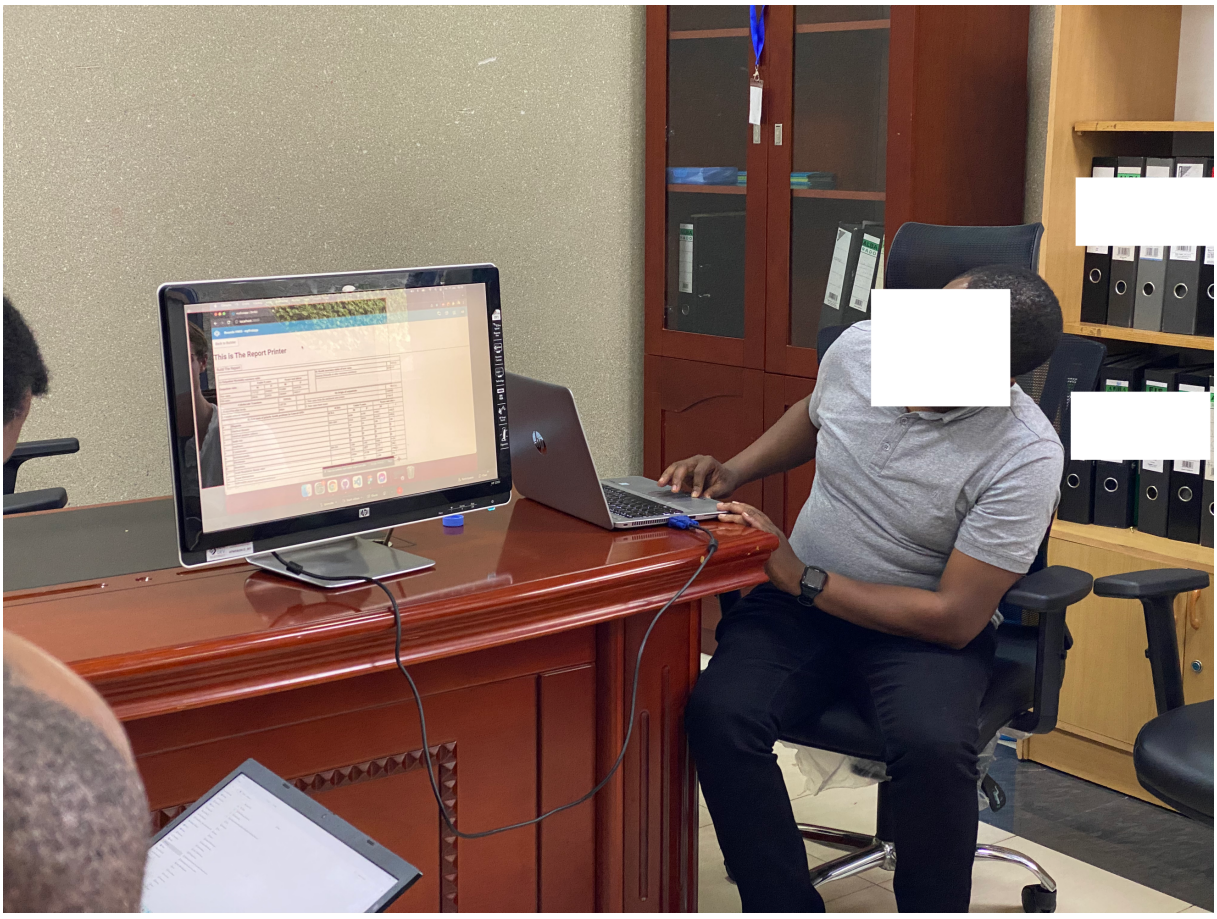


Figure 15 Demo at MoH´s offices

During the first live demo of the MVP, we obtained information that the engagement of a collaboration project was especially interesting for one representative from the MoH.

"*To this project, there is only one thing missing. It is that we should have included our students also, because they have master's in health systems too"*

The representative was referring to the University of Rwanda (UoR) who has close ties to the MoH. His intention was that by collaborating with the UoR we would gain access to users of health information systems in Rwanda. In essence, if we had established such a partnership before arriving Kigali, our prototype might have had sufficient input, and we would have more time to prioritize the development of the Report Builder.

4.3.5 Fieldwork: The perspective of MoH Rwanda

The MoH was frequently visiting the HISP Rwanda office during our field trip. The Report Builder project was just a minor initiative compared to the other ongoing projects at the time. This granted us with access to engage in informal interviews with the representative from MoH. As we have already addressed, there has been introduced two perspectives of the role the Design Lab served in the Report Builder project. The MoH had their own contrasting perspective. It turns out that their perception of the Design Lab´s role was to serve as coaches of agile methodology, to influence the current workflow of HISP Rwanda. During the previous phases of this thesis, this role was discussed and stated as a valuable contribution, but due to the circumstances of the pandemic and the lack of stakeholder engagement, we concluded that it would produce insufficient findings from which we could contribute with. This in itself was a finding for us, and indicates another notion of *communication challenges* as we had failed to communicate our new research objective of "*Explore the current development practice of HISP Rwanda*" to this stakeholder, as well.

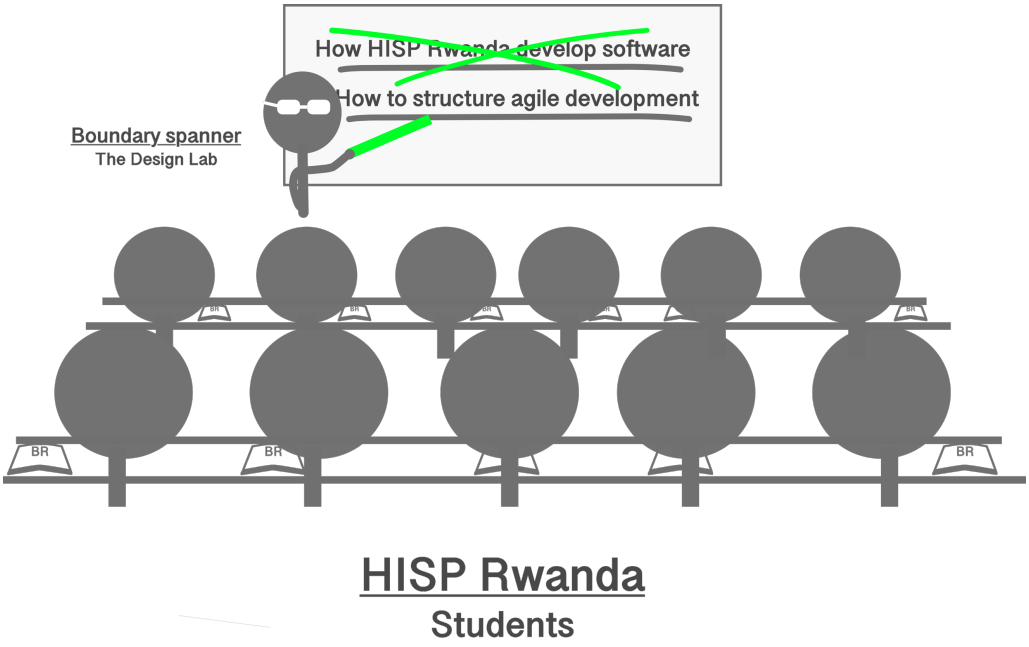


Figure 16 Illustration of MoH's perspective of roles in the Report Builder project

4.4 Phase 4: Assessing the Project and Reformulating the Objective

As the fieldtrip saw its end, we were left with a rather ambiguous set of findings. To tackle this, we had to revisit all our data, from every phase, so to construct an overall understanding of what had happened during the project's lifespan. The activities of revisiting our data and the challenges and findings which affected the objectives of this research is what has been described in phases in the above sections. The result of analyzing the previous phases was the creation of three themes with which we could categorize our data. The themes capturing the findings can be seen in table 5

Theme	Description	Example occurrence
Stakeholder Engagement	The lack of attention to and engagement with the ongoing project, causing delays and other implications to the project's progression	Meeting pushed by two weeks, hindering feedback for next iteration of prototype.

Challenges with Communication	Shortcomings caused by miscommunication, language barrier, bad audio quality, and other hinders in transferring information	Four languages used in live demo of MVP during field trip. Much time used to translate internal discussions
Confusion of Roles	Unclear assignment of primary activities for individuals partaking in the project.	Assumed main developers were poorly defined during fieldtrip

Table 5 Table of the three main themes from our data analysis

4.5 The Challenges with KBRs for Technical BR use

During the master's course mentioned in this thesis where groups of students were tasked with building an application for DHIS2, we found examples of shortcomings in the knowledge resources. During the semester project, teaching assistants (TAs) identified a lack of appropriate development resources that students were to use in their app development. This in turn led to TAs having to shift their prioritization when tutoring to make up for the missing resources, in turn functioning as boundary spanners for the lacks in vendor distributed KBRs. Also, come the end of the semester, feedback from student strengthened the theory of the previously identified shortcomings. The findings suggested issues related to DHIS2 app development documentation, libraries, and other boundary resources. However, findings suggest that the shortcomings do not necessarily concern a lack in existence of resources in DHIS2's boundary resources. Instead, this phenomenon might ground in the immediate availability and accessibility of resources. In other words, the documentation can seem difficult to utilize due to its fragmented nature, the spread of nodes, and 'hidden' edges in the network. Our findings might suggest that the boundary resources on the DHIS2 platform arrive short in their purpose to inform developers using them.

Interestingly, findings from the project analysis uncovered limited use of boundary resources from the Rwandan side, and the request to conduct workshops about them during our fieldtrip further strengthened the notion of lacking KBRs. This sparked an interest in pursuing the capacity of the DHIS2 knowledge boundaries. As such, we conducted seven semi-structured interviews. Four with students that had taken the previously mentioned master's course, two interviews with developers from HISP Rwanda and one with a representative of MoH Rwanda. The objective was now to capture what limitations existed with the current BR and the documentation and other knowledge boundary resources related to them. Data produced from these interviews resulted in conflicting findings about the usability of the knowledge resources. We found that while the knowledge resources were lacking for students, being new to DHIS2 development, the developers from HISP Rwanda were more than satisfied with them. More so, we saw tendencies that when KBRs were used during fieldtrip, they were utilized poorly. The actual extent to this misuse is unknown, but our findings suggest that developers from HISP Rwanda might find themselves with development challenges of which can be resolved if documentation and other KBRs is utilized correctly.

Further, continuing the pursuit of the extent to which the KBRs arriving short, three meetings with various core-team members gave insight into future plans in closing gaps created by knowledge boundaries (German, Kai, Austin). One of the authors of this thesis were tasked with further assessing how to improve the DHIS2 documentation. However, when presenting the findings to representatives at HISP UiO, it was hard to break through with the findings on documentation challenges due to a very busy schedule for other areas to improve the capacity for complementors. This suggested that from identifying the knowledge boundaries to resolving them was a complicated affair.

4.6 Chapter Summary

Table 5 shows examples of the three main Identifying challenges with the existing KBRs were rather straight forward and findings suggest that they would be easily overcome with sufficient attention to improving them. The more challenging part was identifying unexplored knowledge boundaries. Only after the field trip were we able to establish what challenged our position as action researchers and in turn changed our main research objective. Through our engagement in the Report Builder project, our research entered 4 phases all of whom contained different research angles as our findings constantly challenged our current research objective. Phase 1 was the initial entry to the Report Builder application, starting out as a co-development project with HISP Rwanda. Phase two was entered with our interest in exploring the development practices of HISP Rwanda, and how we could conduct an intervening form of research with a standardized software process for complementors. Phase 3 symbolized our biggest moment of realization this far in the thesis, as we embarked on our field trip to Kigali where the main actors of the fieldwork, all were of different understandings of what the Design Labs role in the project was. Lastly the project entered phase 4, the end of this thesis´ timeline, and the melting pot of all our findings from our engaged case study. This last phase of our study summarized our findings, which will be addressed in the next chapter.

5 Analysis & Discussion

This thesis has the main research objective to explore the challenges with knowledge boundaries found in platform ecosystems, and what role boundary spanning can play in this environment. We do so by answering the following research question:

What are challenges for facilitators of boundary spanning activities in a digital platform ecosystem

During our one-and-a-half years of research, we have iteratively redefined our research objectives through an engaged case study, to find an appropriate basis for our theoretical and practical contribution.

5.1 Extending the notion of Knowledge Boundary Resources

Our practical contribution aims to assist in improving the existing KBRs found on DHIS2, and for the creation of new ones. In the following section, we will discuss our findings and propose a model to better capture the need of a broader set of complementors.

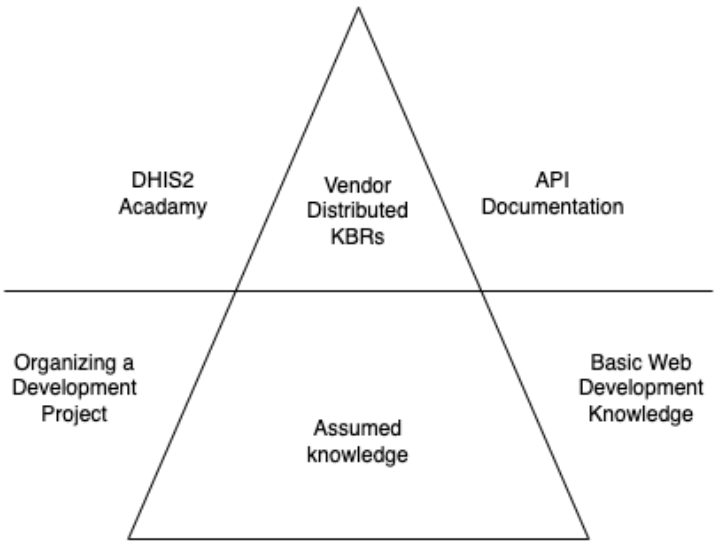
Boundary spanning refers to the activity of bridging knowledge boundaries between organization in a platform ecosystem. Therefore, it is important for both vendor and boundary spanner to understand the knowledge boundaries within the ecosystem, so to overcome challenges related to them. Literature suggests that platform strategies inherently impose knowledge boundaries, and if not addressed correctly, the success of the platform strategy is likely to be endangered (Foerderer et al., 2019). Consequently vendors in a platform ecosystem should pay attention to the knowledge boundaries within their own ecosystem so that their their complementors arent faced with shortcomings in the vendor-distributeed BR, hindering them in either implementation, customization or custom app development. However, in the case of DHIS2, the ecosystem is very large, and with such a heterogeneous set of complementors it is hard to understand how to best identify the various complementors' needs.

However, we have identified other important notions regarding existing knowledge boundaries the DHIS2 vendor may engage in. Firstly, the fact that the developer we were supposed to collaborate with was unable to join in because of lack in development skills in the needed programming language suggests that there are knowledge boundaries related to basic web-development skills not yet apprehended by the existing KBRs. Such an essential knowledge boundary for complementors to be capable of developing custom applications should indicate that there exists sever knowledge boundaries that inhibits the innovation aspect of the platform.

Additionally, our findings from the master's course indicates that there are a number of improvement areas to the existing documentation. Though we understood from the

meetings with core team representatives that the difficulties with prioritizing the voices of the many, also backed in Nicholsonet al. (2021), we suggest that findings from the design lab and findings from the course explicitly working with the platform in focus, articulating generic challenges with the existing KBRs holds great potential for simple tweaks to improve the reach of the KBRs.

We propose a model from which vendors of innovation platforms with a large ecosystem containing vastly heterogenous complementors can use, one that goes beyond the traditional scope in ES platforms. In the model, we classify KBRs into two categories: *Assumed known*, and *vendor distributed*. Our proposal is for innovation platform vendors to ensure that basic web-development knowledge is acquired for all partner organizations, even if this means that the vendor should place assumed knowledge into the vendor-distributed category. This way, the creation of such KBRs should take less effort than that to assist complementors when they have basic web-development skills.



Knowledge sharing through boundary spanning is an activity that can solace the complex activities of maintaining implementation and the continued expansion of the digital platform. Through boundary spanning, facilitators convey knowledge boundary resources between actors within an ecosystem. In this thesis, following an application development initiative, the knowledge boundary resource is in the form of a model for a software development life cycle. The model targets work practices and the processes involved in app development. As such, building an understanding of the target actors and the socio-technical differences between them before and during spanning can in many ways affect the outcome.

5.2 Contribution

Our theoretical contribution aims to extend the notion of boundary spanning to facilitate for the transfer knowledge where broadcasting KBRs fail. We position the following sections as lessons to learn from as our main contribution.

5.2.1 The challenges with stakeholder engagement

A persistent challenge of pertaining engagement from stakeholders were prominent. Unforeseen situations such as mass vaccination due to the sporadic nature of covid-19 would of course be justified, but still very visible to the progression of the application. The consistent delay in meeting times, confusion of meeting dates, and lack of constructive feedback also affected our attempts in boundary spanning. Additionally, frequent postponement of pre-set meetings, and the frequent request for on-the-spot meetings, made further complications for the advancement of the prototype, seeing that we longed for much needed input on the project status. These challenges were also quite prominent during our fieldtrip, in which a number of planned activities had to be postponed, delayed and even cancelled. So, we propose the consideration of early establishment of what to be expected from the stakeholders

5.2.2 The challenges with communication

A major complication to the information stream between us students and other stakeholders was the challenges relating to communication. For one, meetings with the other half of the development team were often characterized by bad audio quality when using digital meeting grounds. This inhibited our communication in more ways than we knew. Also, when stakeholders different from the typical developer team joined in on the meetings, a large portion of this time was used to translate and clarify what was being said between the different actors. Sometimes we were not even aware of what people were discussing in such meetings before a new topic was brought up, and backtracking to the previous conversation was next to impossible. We found the same challenges quite frequently also during out fieldtrip. For instance, the simple task of contacting a core team members using zoom was quite difficult due to the varying network connections we had at the office in Rwanda. On this note, we propose the consideration for spanners to prepare for instances with shortcomings in communication

5.2.3 The confusion of roles

The assignment of specific roles during a development project is important. Similarly, for us to be able to learn from and bridge knowledge boundaries related to software development practices within the DHIS2 ecosystem, it is vital that we pertain our roles as engaged observers and not the main developers. One of our more important findings is that the project side-tracked mainly due to the challenges with confusion of roles. Our biggest challenge in this sense was the lack of a designated project owner. Findings suggest that the three themes presented is greatly linked, and from challenges with communication, the confusion of assigned roles Is obvious. Our challenges with this theme were not so much the result of role not being assigned, but more due to the attachment individuals had to the roles, caused by unsatisfactory communication. Also, in this confusion, the absence of project ownership became present. In turn, leading to further stakeholder disengagement. And so, we propose the consideration of spanners to be clear in what their objectives are, early.

5.2.1 Considerations for Boundary Spanning Facilitators

As a summary, our most sincere advice is for the boundary spanner to conduct a thorough investigation of the subjects in the spanning project. This was something we lacked in ours and something which caused major complications for the outcome of our learning potential. This is especially important for spanners inside the DHIS2 ecosystem, seeing the diversity in partner organizations herein. Although our research approach and findings were constantly changing, and seemingly chaotic, this was not only due to challenges caused by our subjects, rather, a major denominator in this chaotic environment was the shortcomings from our side in proper investigation of the partner organization. Further, when initiating the project, facilitators should ensure that all stakeholders involved have a designated role during the boundary spanning activities, and that there is clear engagement from the stakeholders. We look back at the second and third phase of our project with information which would dramatically change the course of our fieldtrip. However, the boundary spanner should be vary of the three themes motioned in the findings: Confusion of roles; Challenges with Communication; And Challenges with stakeholder engagement.

As a summary, our most sincere advice is for the boundary spanner to conduct a thorough investigation of the subjects in the spanning project. This was something we lacked in ours and something which caused major complications for the outcome of our learning potential. This is especially important for spanners inside the DHIS2 ecosystem, seeing the diversity in partner organizations herein. Although our research approach and findings were constantly changing, and seemingly chaotic, this was not only due to challenges caused by our subjects, rather, a major denominator in this chaotic environment was the shortcomings from our side in proper investigation of the partner organization. Further, when initiating the project, facilitators should ensure that all stakeholders involved have a designated role during the boundary spanning activities,

5.3 Limitations

In this section, we will address the limitations of our research.

5.3.1 The COVID-19 Pandemic

This study has been conducted during the COVID-19 pandemic. The pandemic disrupted civilization globally, as governmental measures to prevent the virus from spreading resulted in lockdown and closed public institutions, our research was also victims of restrictions. The complications of the virus had a severe impact on our research in terms of international regulations for travel, haltering our much-awaited field trip to Kigali which ideally would be led in the initiation of the collaboration project. If not for the travel ban, the findings and experiences of this thesis, would be entirely different – as we would have more time in Kigali to conduct or fieldwork, clearing up the continuous but arguably simple misunderstandings, presented in Chapter 4.

5.3.2 Methods

Our engaged case study is mostly based on three main methods of data inquiry. For nearly one year, our main source of observation data was obtained from attending zoom meetings. As interpretive IS researchers our findings are based on the subjective reality of our research subjects. By being restrained to observe within a digital world, our data collection was victim to collection of poor data quality. As most of our research involved the study of HISP Rwanda, our lack of access to impacted our insight to their practices, making us having to assume some knowledge, without being able to confirm it first hand.

5.3.3 Field trip

Our field trip even though greatly appreciated, considering the circumstances, was within a relatively short time span. As mentioned in chapter 4, we had only twelve days to conduct our fieldwork, where we were victims of poor project management – mainly

due to our own passive stance of not raising questions when we constantly experienced unfortunate themes which inflicted our own stakeholder engagement.

5.4 Further research

Though our findings are not sufficient in proposing a solution to knowledge boundary challenges, we promote upcoming scholars on this subject to continue the investigation of how to identify knowledge boundaries.

To further compliment this thesis we suggest that further research explores our finding from our fieldtrip in Kigali. As mentioned, the MoH was eager to introduce us to the university of Rwanda, as such a collaboration would be fruitful for our research in terms of access to end-users of HMIS, but also insight to domain knowledge local to Rwanda.

In addition, our findings from our misunderstanding with HISP Rwanda, uncovers a new potential for boundary spanning within DHIS2 BR. While considering there was a need for capacity building of React development in HISP Rwanda. This study has findings from the UiO course IN5320 which facilitates boundary spanning of React development on the DHIS2 platform. As mentioned, this course is facilitated by the Design Lab as the lab provides BR for the students to utilize. We suggest it could be a potential to establish a Design Lab in Rwanda with engagement of both HISP Rwanda, and the University of Rwanda – a similar symbiosis to the Design Lab Oslo and HISP Centre. The collaboration could be a way for HISP Rwanda to develop local capacity building, while simultaneously exposing the DHIS2 software to students

6 Conclusion

This thesis has explored how knowledge boundaries can inhibit the further customization and development of custom apps, and how KBRs and boundary spanning can assist in overcoming challenges related to such boundaries. This was explored during the development project of a custom app in collaboration with developers and implementation specialists from the partner organization HISP Rwanda. This assisted us in understanding the challenges with bridging a knowledge gap through boundary spanning.

We discussed three main considerations for upcoming boundary spanners to leverage from, these contributions are as follow:

1. Early establishment of what to be expected from the stakeholders
2. Prepare for instances with shortcomings in communication
3. Be clear in what the spanners' objectives are, early

Further, we propose a model from which vendors of innovation platforms with a large ecosystem containing vastly heterogenous complementors can use, one that goes beyond the traditional scope in ES platforms. In the model, we classify KBRs into two categories: *Assumed known*, and *vendor distributed*.

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