Utilizing the Space for User Participation

Enabling and Constraining Factors for User Involvement when Designing a Data Entry Interface in a Generic Health Information Software in Uganda

Magnus Li

Thesis submitted for the degree of
Master of Informatics: Design, Use, Interaction
60 credits

Department of Informatics

Faculty of Mathematics and Natural Sciences

UNIVERSITY OF OSLO

Spring 2018

Utilizing the Space for User Participation

Enabling and Constraining Factors for User Involvement when Designing a Data Entry Interface in a Generic Health Information Software in Uganda

Magnus Li

2018

Utilizing the Space for User Participation

http://www.duo.uio.no/

Printed: Reprosentralen, University of Oslo

Abstract

This thesis investigates which technical and organizational factors that enable or constrain user participation in design when implementing a generic health information software. More specifically, it focuses on user participation during the design of a data entry interface for health commodity ordering using the generic software DHIS2 in Uganda.

User participation in design can be a measure of ensuring interfaces that suit the established knowledge and practices of the end-users. However, generic software packages are often used in health information systems, and their generic nature poses a challenge to the development of interfaces that are sensitive to local particularities. To enable local user participation when implementing such systems, existing literature argues that software and projects need to provide ‘space’ for participation.

In a two-year Action Research project, the implementation in Uganda was investigated and further strengthened by developing a prototype for a new data entry interface through a participatory approach with health workers and managers. The empirical findings of this thesis indicate that a set of interdependent socio-technical factors interact to enable or constrain the potential, as well as the utilized level of user involvement in the implementation of generic software. Central are technical flexibility provided by *customization capabilities* in the software, and the organizational capability for utilization of this flexibility, which is formed by factors such as levels of project autonomy, motivation, time and financial resources, competence and the participatory culture of the involved actors. Together, these factors shape the actual space for local customization and user participation. Moreover, four potential positive outcomes of user participation in the design of data entry interfaces have been identified from the empirical case. These include increased fit between technology and work, increased user acceptance and work satisfaction, increased data quality, and promotion for integration with other health programs.

The contribution of this thesis is twofold: practically, the prototype produced during the project can further help strengthening the commodity ordering system used throughout the public health system in Uganda. Moreover, learnings from the participatory process analyzed in light of existing literature form the theoretical contribution. These are outlined and discussed as concrete enabling and constraining factors, and indications of how participation in data entry interface design can be relevant to health information systems strengthening.

Keywords: user participation, space, customization, generic software, data entry interfaces, health information systems, developing countries.

Acknowledgments

First of all, I would like to thank my supervisor Johan Ivar Sæbø for great guidance and encouragement in a project which has been increasingly intriguing. I will further thank the rest of the Information Systems research group at the Department of Informatics at the University of Oslo for all their help and support, especially Petter Nielsen, Terje Aksel Sanner, and Ola Hodne Titlestad. This research has unfolded in cooperation with many people. For one, the HISP team in Uganda has played a significant part of this research, and I will especially like to mention Prosper, Monica, Andrew, Brian, Alex, and David. Moreover, my fellow researcher Nicolai has been a great companion during all the field-work in Uganda, and the health workers and managers at clinics, hospitals, warehouses, district offices, and the Ministry of Health that have participated in the project have made considerable contributions and made the process inspiring.

Also, several fellow students, researchers, and friends have contributed with interesting discussions and/or proofreading during the process of writing, such as Joshi, Preben, Marte, and Alexander.

Finally, I would like to thank my friends, family, and Vilde for magnificent support and encouragement throughout the process.

Magnus Li
University of Oslo
March 2018

Table of Contents

List of Appendices

List of Figures

List of Tables

Abbreviations

ARV	Antiretroviral (for treatment of HIV)
DHO	District Health Office/District Health Officer
DHIS2	District Health Information System 2
HIS	Health Information System
HISP	Health Information Systems Program
HMIS	Health Management Information System
II	Information Infrastructure
ICT	Information and communications technology
IS	Information System
JMS	Joint Medical Stores
LMIS	Logistics Management Information System
MSH	Management Sciences for Health
NMS	National Medical Stores
PD	Participatory Design
SURE	Securing Ugandans' Right to Essential Medicines
UiO	University of Oslo
USAID	United States Agency for International Development
WAOS	Web-Based ARV Ordering and Reporting System

Chapter 1 - Introduction

Based on a two-year Action Research project, this thesis looks at the challenge of designing good data collection tools in the health sector. More specifically, it discusses which technical and organizational factors that might enable or constrain user participation in the design of data entry interfaces in a generic software package. User participation in data entry interface design is relevant as it is argued that the layout of such interfaces should suit the established knowledge and routines of the health workers that use them. When failing to provide sufficient clarity; data quality, timeliness, and work satisfaction might suffer. Generic software packages are relevant as they are increasingly important components of health information systems (HIS) in developing countries. However, their generic nature poses a challenge to the development of interfaces that are sensitive to local particularities. In the empirical case of this thesis, we follow a project in Uganda, which has implemented a working health commodity ordering system using the generic software package DHIS2. This has enabled improved flow of information to relevant decision-makers, but lack of clarity in the generic data entry interface used by health workers introduced issues affecting work satisfaction and data quality. As an attempt to address these problems, a new data entry interface was designed through a participatory approach by engaging health workers in the process. The factors that enabled or constrained this process is discussed.

1.1 Motivation

Countries are reliant on a functioning health system to ensure the well-being of their citizens. Still, many developing countries are struggling with challenges limiting their ability to provide sufficient health care. For example, many hospitals and health clinics suffer from frequent stock-outs of essential medicines used in the treatment of fatal diseases such as HIV (Umlauf & Park, 2018). Some of these challenges are related to the lack of sufficient information used in managerial, administrative, and clinical decision-making. Thus, improving the collection, flow, and use of timely and high-quality information is of great significance to strengthening health care (AbouZahr & Boerma, 2005). HIS enable collection, transfer, analysis, and presentation of such health-related information, but several challenges are related to this in a developing country context. Data quality and information use are low, and the overall system is fragmented due to vertical reporting regimes initiated by disease-specific health programs (Chilundo & Aanestad, 2005; Lippeveld, 2001).

Information and Communication Technologies (ICTs) are increasingly used for collection of data in HIS, due to decreasing hardware prices and improved internet connectivity enabled by mobile network technology (Sæbø, Kossi, Titlestad, Tohouri, & Braa, 2011). For example, increased network coverage and improved infrastructure in Uganda has enabled implementation of the generic software package DHIS2 to support computerized data entry of orders of HIV-related commodities for health clinics and hospitals. However, this means that ICTs are introduced to health workers with limited experience in computer use. Research on HIS strengthening argues that the simplicity and clarity in the layout of the data collection tools in HIS can have an impact on data quality and work satisfaction (Lippeveld, Sauerborn, & Bodart, 2000). Hence, to provide clarity, the data entry interfaces of such computer-based systems should ideally be designed to support the particularities of existing work practices of the domain and context of the health workers that use these tools for data reporting. Without sufficient knowledge of these contextual factors, software developers and implementers might build and introduce systems that are inefficient and unreliable (Heeks, 2002). In Uganda, the layout of the digital interface used by health workers to enter data did not match existing practices and failed to provide simplicity and clarity, which was reported to affect data quality and work satisfaction.

Engaging such health workers when designing data entry interfaces is argued to be one way of promoting clarity in the final layout of digital data collection tools of computer-based systems (Lippeveld et al., 2000). This argument is in line with an extensive body of literature on user participation or *involvement* in the design of information systems (Kujala, 2003). User participation refers to *"the involvement of users in work activities during system development"* and aims at *"involving future users of a computer-based system in decisions during system development"* (Bjerknes & Bratteteig, 1995, p. 73). One of the main arguments is that including users in the design process can increase fit between digital technology and established work practices (Damodaran, 1996; Kujala, 2003).

Generic software packages such as DHIS2, that are developed and maintained through global projects are however often essential components of HIS (Braa, Hanseth, Heywood, Mohammed, & Shaw, 2007; Braa & Sahay, 2012a), where they among other things provide interfaces for data collection. Generic software often referred to as 'off-the-shelf software' or 'application packages,' is here defined as *"systems designed for general use, as opposed to custom systems, designed for a specific user or group of users"* (Bansler & Havn, 1994, p. 708). Since data entry interfaces of such systems are designed and standardized to work across a wide range of use cases, it is a challenge to implement layouts that are sensitive to existing local routines and domain-specific requirements based on knowledge established from user participation in the design (Bansler & Havn, 1994). A body of literature suggests that such software and the developing and implementing organizations involved can enable local user participation in the design by providing technical and organizational flexibility or *space* (Fischer, 2008; Kimaro & Titlestad, 2008; Roland, Sanner, Sæbø, & Monteiro, 2017). For HIS development in developing countries, literature mainly focuses on how software packages and their surrounding social architectures can be designed to support distributed and large-scale user participation to inform the design of the generic application itself, and how space is provided for local customization. There is, however, limited empirical research investigating how these mechanisms for flexibility affects local implementation projects, and which factors, both technical and organizational, that enable and constrain these local implementations in engaging end-users in design activities.

1.2 Research Question

Based on the described problem, the research question of this thesis is:

Which factors might enable or constrain user involvement when designing data entry interfaces in a generic health information software?

Factors refer to socio-technical aspects that 1) enable or constrain flexibility for local customization in the generic software, and 2) affects utilization of this flexibility, thus, together shaping the space for participation.

To answer this research question the primary objectives are to 1) investigate how the existing commodity ordering system and its data entry interface have been designed, and what role user participation played in this process, 2) to develop a new data entry interface trying to involve health workers and data entry personnel in design, and 3) to analyze these processes to identify relevant technical and organizational factors that enabled or constrained user participation.

Through a two-year Action Research project, the established health commodity ordering system in Uganda was investigated, and I, as an involved researcher actively participated in the process of improving the data entry interface with emphasis on user participation in the design of the layout. Grounded in learnings from this Action Research project and existing research literature on HIS strengthening and user participation in information systems design, this thesis discusses both technical and organizational factors that enable or constrain the ability to involve health workers in the design of a data entry interfaces in the organizational context and DHIS2. DHIS2 is used in a variety of use cases in over 50 developing countries and is developed and managed by the global Health Information Systems Program (HISP). Moreover, the empirical findings indicate some positive outcomes of user participation in data entry interface design, which are discussed in relation to existing literature on HIS strengthening.

With this, and in line with the goal of Action Research, to provide learnings of value both to practice and theory (Baskerville & Wood-Harper, 1996), this thesis aims to contribute both directly to the ongoing HIS strengthening in Uganda, the HISP project, and the broader field of research on HIS strengthening and user participation in information systems design. First, concrete suggestions for improved design can feed into the further strengthening of the commodity ordering system. Second, experiences from the participatory process might strengthen competence in the local developing team. Third, the factors identified as enabling and constraining for user participation in the design of generic software and large-scale projects in a developing country context provide rich insight to how this 'space' is formed and might be utilized in local implementation initiatives. This insight contributes to research by supporting prior literature, extending this understanding with empirical knowledge, and further providing basis for future research on this topic.

Eventually, the theoretical contribution may help to promote an extended focus on such challenges in HIS strengthening initiatives. In turn, by improving simplicity and clarity in computer-based data entry interfaces through user participation in design, this could contribute to better data quality, and eventually, the overall goal of strengthened healthcare.

1.3 Chapter Summary

Chapter 2 – Background

Provides a general background for the project. The HISP project will be introduced, and key information about Uganda will be outlined.

Chapter 3 – Related Literature

Introduce relevant literature to provide an understanding of 1) information systems and HIS, 2) HIS challenges, 3) user participation in information systems design, 4) user participation and customization in generic software packages and large-scale projects, and 5) user participation in a developing country context. The understanding established from this, and theoretical concepts outlined, provide the theoretical lens used when analyzing and discussing the empirical findings.

Chapter 4 – Methodology

Describes and justifies the selected methodology, methods and techniques used in this project, and outline how these were used for data collection.

Chapter 5 – Results

Related to the two first objectives of this thesis, results from the diagnostic, action and evaluation phase of the Action Research project are presented.

Chapter 6 – Analysis and Discussion

Draws on the results of the Action Research project to address the third objective: to analyze and discuss enabling and constraining factors for user participation, and possible positive outcomes identified. Moreover, reflections upon the research conducted, implications, and limitations will be discussed.

Chapter 7 – Conclusion

Concludes the thesis by summarizing main findings and reflects on future work.

Chapter 2 - Background

The research of this thesis has been part of the HISP project and concerned with a health information system in the public health sector of Uganda. Here the use of the District Health Information Software 2 (DHIS2) as a commodity ordering system was investigated and further developed. This chapter will provide a brief background on the HISP project, DHIS2, and Uganda.

2.1 The HISP Project and DHIS2

The Action Research project of this thesis has been a part of the Health Information Systems Program (HISP), which is a global research and health information systems (HIS) strengthening project, where primary goal is to "*design, implement, and sustain HIS following a participatory approach to support local management of health care delivery and information flows in selected health facilities, districts, and provinces, and its further spread within and across"* (Braa, Monteiro, & Sahay, 2004, p. 343).

The project constitutes a network of HIS implementation and strengthening capacity, with nodes in several countries in Africa and Asia, including Uganda. The University of Oslo (UiO) have a significant role in this network, coordinating software development, arenas for competence building and sharing, and funding of these activities. Every year, UiO engage several Master and Ph.D. students from a variety of countries to do research activities in the involved countries, both contributing to local implementation and research.

2.1.1 Origin

HISP is explicitly rooted in the Participatory Design (PD) and Action Research tradition and therefore emphasizes user participation in design through projects that both benefit the implementation initiatives and a broader research agenda. As these are of further relevance to this study, PD and Action Research is described in detail in Chapter 3 and 4. The HISP project began in post-apartheid South Africa, where the aim was to develop a health management information system in three districts through cooperation between researchers from the UiO, local universities, and activists. The political climate after the diffusion of apartheid laws proved to fit well with the discourse of empowerment and participation emphasized by the PD tradition (Braa & Sahay, 2012b). After successful pilots in three districts, the project spread to several districts and eventually became an official national system in South Africa.

The main challenges in South Africa regarding HIS was a highly fragmented landscape of centralized reporting regimes, where little of the collected information was in use at the district level. Based on this, the main goal of the HISP project in South Africa (and later in other countries), was to 1) define an essential integrated data set, a standard for what data that is to be collected, and, 2) development of a software (DHIS) to support data collection, analysis, and presentation, which further can be integrated with other data sources such as population data. For the software, this initial development process took form as an evolutionary PD process *"carried out in line with PD practices, and a series of increasingly refined prototypes were tested in close collaboration with users, to enable information for local action."* (Titlestad, Staring, & Braa, 2009, p. 9)

As similar challenges were experienced in other countries in the global south, HISP got involved in HIS strengthening initiatives in Mozambique, India, and eventually a variety of countries. While the first countries were involved by directly establishing nodes with local DHIS2 and HIS development and implementation competence in the respective countries, some of the later countries like Malawi got engaged in the network by implementing DHIS independently. While doing so, they established contact with other nodes in the HISP network and benefited from competence and experiences from their implementations. Over time, the network grew into a global project of development and implementation.

2.1.2 DHIS2

As the initial development of DHIS was based on requirements gathered through participation in South Africa, it provided a close fit with this local context. However, when moving to other countries, the software architecture proved to be inflexible for transfer to different contexts. This triggered a redesign process where developers from South Africa developed DHIS 1.4 based on requirements gathered from implementation teams in Botswana and Zanzibar (Braa et al., 2004). Version 1.4 was built using Microsoft Access as a vital component which is distributed under a preoperatory software license. To avoid dependencies to proprietary software and to make the application fully open source, it was later redeveloped from scratch using open source software technologies, resulting in DHIS version 2. While expanding to even more countries the software architecture needed further flexibility, and over time the software evolved to a modular platform. The platform architecture enabled the core developer team in Norway to develop core functionality, and local implementation teams to adapt the software to work in local settings.

Today DHIS2 is as of early 2018 used on a national scale in over 55 countries and is piloting in 34 more, to collect, store, analyze, and visualize data for a variety of health programs (DHIS2.org, 2018). It is developed and coordinated from the UiO in Norway, and distributed under the Berkeley Source Distribution (BSD) open source license. The BSD license is highly liberal in that everyone can modify and redistribute the software, even under a more restricted license (Linfo.org, 2005). Hence, developers and implementers can change all aspects of the software package to suit particular needs and requirements.

Commonly, the DHIS2 is used as a data warehouse that store data from various sources such as other HIS software, mobile and web-based data entry applications and so forth. In turn, this data can be analyzed and visualized through several built-in applications such as maps, dashboards, and pivot tables. This is often made accessible to relevant actors such as Ministry of Health, district health offices, health clinics, and international donor agencies through a web-based portal. Figure 2-1 illustrates DHIS2 as a centralized data warehouse.

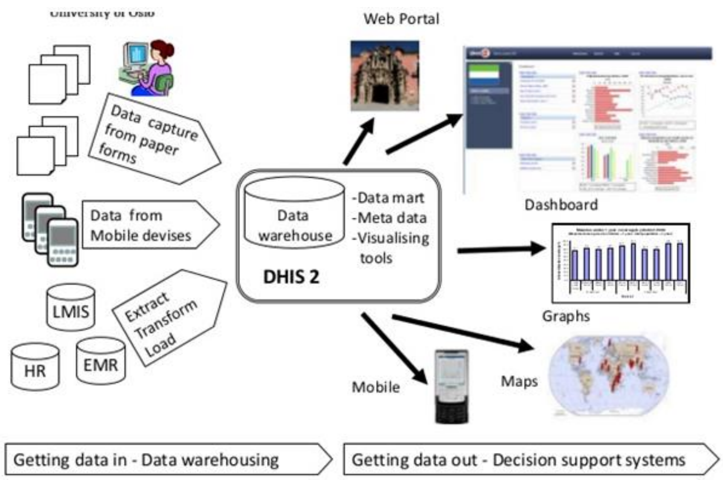


Figure 2-1 DHIS2 as a data warehouse (from hispuganda.org)

2.1.3 HISP Today

With the evolution of DHIS2, the HISP project has evolved to an extensive network of nodes in a variety of countries. These customize and implement the software in the local context, and feed requirements and experiences back to the core developers through various arenas of competence sharing such as workshops and mailing lists (Titlestad et al., 2009). Braa et al. (2004) describe the network as a horizontal level of loosely coupled countries, and with different institutions within these countries connected vertically, such as local ICT consultants, health professionals, and government officials. Participants of these nodes often travel between countries to help develop local competence in other nodes and implementation projects. Local universities also take part in this network, offering master programs in HIS strengthening, funded by Norwegian Agency for Development Cooperation (NORAD) and other partners. Moreover, UiO offers Ph.D. programs where participants of the network do research in their respective countries and are awarded a doctoral degree.

The research project of this thesis has been a part of this network and engaged in Uganda where the local node 'HISP Uganda' is established. This organization and their relation to the global HISP project is further described in the results (Chapter 5).

2.2 Uganda

HISP has been engaged in Uganda for several years, and the empirical case of this thesis is based on HIS strengthening in this country. This section will provide a brief background of Uganda.

Uganda is a land-locked country in East-Africa with a population of about 39 million. It is bordering Kenya in the East, The Democratic Republic of Congo in the west, South Sudan in the north, and Rwanda, Tanzania, and the Victoria Lake in the south (Figure 2-2 provide a map of Uganda). The country is rich in a variety of natural resources with frequent rainfalls, large reservoirs of fresh water, and fertile soil. Since it gained independence from Great Britain in 1962 the country has however struggled with developing a stable society. The borders of the nation were drawn during colonization, and as a result, the variety of ethnic groups with diverse cultures have made the establishment of a stable government difficult (Central Intelligence Agency, 2018). Several periods after the decolonization are characterized by political instability and suppressing dictatorships, such as the regime of Idi Amin from 1971 to 1979, and Milton Obote from 1980 to 1985. Under the ongoing continuous rule of Yoweri Museveni from 1986, the country has experienced increased stability and steady economic growth. Still, the country is subject to deep-seated issues regarding economic self-reliance, corruption, human rights, freedom of speech, infrastructure, education, health, and poverty (NORAD, 2015).

Figure 2-2 Map of Uganda (from africa.com)

Most of Uganda's population lives in rural areas, and 71.9% of the labor force is occupied in agriculture (Central Intelligence Agency, 2018). In these areas, the inhabitants mostly live off the resources they can grow and produce themselves. Kampala, the capital city, has a population of around 1,9 million citizens. Although the Ugandan economy has been growing steadily in recent years, the country still has one of the lowest gross domestic product (GDP) at purchasing power parity per capita (PPP) in the world, about 2,400 USD in 2017. In comparison, the PPP of neighboring Tanzania is 3,300, South Africa 13,400, and in Germany 50,200 USD.

2.2.1 Infrastructure

The economic challenges in Uganda are reflected by the current infrastructural conditions. The overall quality of roads is highly varying, and most areas experience electric power cuts daily. Landline internet is also a limited resource, but mobile data communication technology such as 3G and 4G make internet increasingly available through several private providers in both cities and rural areas.

2.2.2 Health

With an average life expectancy at birth of about 59 years (WHO, 2018), Uganda has a long way to go ensuring a reliable health system to their population. But there is progress, and significant improvement is seen in critical areas. For example, Uganda has been relatively successful in limiting the spread of HIV. New HIV infections per year have decreased from around 140,000 in 1990, to 52,000 in 2016. Patients infected with the virus that receive antiretroviral therapy (ART) has increased from 20 % in 2010 to 67 % in 2016 (UNAIDS, 2018), which has been enabled by providing free ART treatment to the population, supported by international aid. However, HIV is still one of the leading causes of death in the country, responsible for an estimate of 28,000 deaths in 2016 (UNAIDS, 2018). Furthermore, other deceases and infections such as bacterial diarrhea, hepatitis A and E, typhoid and dengue fever, and malaria are common and put pressure on the health system (Central Intelligence Agency, 2018; WHO, 2018).

The health system comprises both public and private services. The private sector can be categorized into either non-profit organizations, for-profit organizations, or faith-based organizations (Ministry of Health Uganda, 2018). Since a sizable portion of the population live in rural areas, where agriculture is the primary occupation, free, public health services are essential in enabling available health care. However, the public health system struggles with challenges due to underfunding, limited infrastructure and scarce access to human resources such as doctors and nurses. The Ministry of Health is the government organization in charge of policy formulation and coordinating the overall health system. The organization consists of several departments in charge of areas such as finance and administration, planning, clinical services, community health, and quality assurance. Also, it is further structured into several programs in charge of targeting specific deceases. Examples of such programs are the Malaria Control Program, the AIDS Control Program, the TB/Leprosy Control Program, and the Uganda Guinea Worm Eradication Program. These programs are often funded in cooperation with international donor agencies (Ministry of Health Uganda, 2018).

DHIS2 in Uganda

Uganda has since 2012 been exploring the use of DHIS2 to strengthen their HIS. As internet access has increased significantly throughout the country, facilities in a variety of districts now report routine and patient-follow-up data to a central DHIS2 national server. This data is used by decision-makers at the local level and in the Ministry of Health to improve resource allocation and health coverage (Open Health News, 2017). Many of these implementation initiatives are supported by HISP Uganda. The case of study in this thesis is one of these initiatives and will be described in detail in chapter 5. First, we turn to related literature and the research approach of this thesis.

Chapter 3 - Related Literature

This thesis aims to identify and discuss factors that might enable and constrain user participation when designing a data entry interface in a generic health information software in Uganda. We thus need to establish an understanding of health information systems (HIS), user participation, and generic software packages developed through large-scale development and implementation projects. Accordingly, this chapter will present existing research literature related to (1) information systems and HIS (2) HIS challenges, (3) user involvement in information systems design, (4) user involvement in the design of generic software, and (5) the contextuality of user involvement. In the final section, the most important theoretical concepts used in the analysis and discussion are summarized.

3.1 Information Systems and Health Information Systems

HIS are part of the broader term information systems. How we perceive such systems defines our scope of analysis and ability to understand their inner workings, success, and failure. This section will briefly introduce the underlying understanding of information systems adopted in this thesis, before turning to a description of HIS.

A system can be defined as *"any collection of components that work together to achieve a common objective"* (Lippeveld et al., 2000, p. 2). Information systems are hence collections of components that support collection, transfer, analysis, and presentation of meaningful information. The perspective on information systems in this thesis sees such systems as socio-technical systems, that is, they consist of both digital and analog technologies, humans, work routines, institutions, and organizations. Large-scale information systems are often shared and open in that there are no clear boundaries of which components that are part of the system, and what actors that are involved in shaping its evolution (Hanseth & Lyytinen, 2010). They are heterogeneous in that they consist of components of different forms, such as humans, organizations, technology, work practices and so on. As governance is often shared between a variety of actors, they are further continually evolving with no single body controlling its direction (Nielsen & Sæbø, 2016). With this, it is argued that such systems are never built from scratch. There will always be some existing components that affect further development and evolution. For example, when introducing new software for data collection in a health-care setting, the current organizational arrangements, health workers, paper routines, and so on will both enable and constrain development, implementation and its relative success.

This fundamental view of information systems as socio-technical systems provide the basis for understanding the challenges and technical and organizational factors in this thesis.

3.1.1 Health Information Systems

HIS is defined by Lippeveld et al. (2000, p. 3) as *"a set of components and procedures organized with the objective of generating information which will improve health care management decisions at all levels of the health system",* and play a crucial role in a working health system (AbouZahr & Boerma, 2005; Lippeveld, 2001). As defined by Lippeveld, its main goal is to support information-based decisions through collection, transfer, aggregation, and presentation of data from different sections of the system.

HIS is a general term, covering a variety of more specific types of information systems relating to health, which each aims at providing information on distinct aspects of the health system. Examples are laboratory systems, medical records systems, logistics management information systems (LMIS) and health management information systems (HMIS). In developing countries, these systems often consist of a combination of digital and paper-based tools. Transportation of data and information occurs physically, or digitally by email or through storage in central databases (Sæbø et al., 2011). Further, different health domains might provide different requirements for the supporting information system, based on who uses the information, how it is collected, and the format of data (Nielsen & Sæbø, 2016). For example, HMIS focus on information in use for management or administrative tasks of the overall health system, rather than in clinical use for specific patient follow-up systems or logistics and laboratory systems to support daily operations. Data is collected for managerial use in decision-making related to health services, to enable evidence-based action, rather than on intuition or political currents (AbouZahr & Boerma, 2005; Lippeveld, 2001). In the words of Nielsen and Sæbø (2016, p. 140) *"In most cases, this means that a subset of service and performance data for health facilities is collected monthly, aggregated for administrative levels such as a district, region or country, and analyzed with regard to trends and outliers, and evaluated against goals and targets".*

Another example of a certain type of HIS is logistics management information systems (LMIS). In a health system-context, LMIS supports the health commodity supply chain, and are therefore concerned with both administrative and managerial information that supports planning of, and the distribution of health commodities (Bergum, Nielsen, & Sæbø, 2017). Contrary to HMIS, LMIS systems therefore need to be designed to support administrative tasks, such as stock management and commodity dispensing at facilities and warehouses, and also, for managerial functions such as procurement and forecasting (Nielsen & Sæbø, 2016). These differences in logic imply that generic software aiming to support several HIS domains need to be highly flexible regarding the design of data structure, data presentation, and data entry interfaces. We will explore this point more extensively later in this chapter. First, we will look at some shared challenges with HIS in developing countries that are relevant to data entry interface design.

3.2 HIS Challenges and Strengthening

Developing countries, such as Uganda, often experience somewhat similar challenges related to HIS, HMIS (Braa & Sahay, 2012a; Sæbø et al., 2011) and LMIS (Bergum et al., 2017; Umlauf & Park, 2018; Windisch, Waiswa, Neuhann, Scheibe, & de Savigny, 2011). This section will introduce some of the challenges typically experienced with HIS in a developing country setting, and some strategies for strengthening that is related to the focus of this study.

Lippeveld et al. (2000) summarize the variety of HIS challenges in developing countries through five main points:

1. Irrelevance of the information gathered: data is collected regardless of information use, resulting in the collection of irrelevant information, and lack of relevant information on other subjects.
2. Poor quality of data: due to limited technical skills and training of personnel, lack of equipment, and low motivation for data reporting at the point of data entry, the quality of data suffers.
3. Fragmentation: limited coordination between health programs and initiatives results in parallel reporting regimes.
4. Lack of timely reporting and feedback: due to delays in reporting, processing, and transfer of data, information is delivered to the decision-makers too late to be of relevance.
5. Poor use of information: even when available, information is not utilized on a routine basis in decision-making. The reason seems to be structural and cultural in that the centralized nature of health systems limits information use at the district level. Also, a limited information culture promotes decisions based on intuition and political agendas.

As we will see later in this chapter, poor data quality (2), fragmentation (3) and issues with timeliness can be related to data entry interfaces and are therefore of particular relevance. Accordingly, they will be discussed in further detail in the following sections.

3.2.1 Fragmentation

The health sector in developing countries is often heavily reliant on international donor agencies. With little trust in data collected through the national and other existing HISs, donor-funded health initiatives build their own reporting regimes, resulting in a highly fragmented field of HIS (Nielsen & Sæbø, 2016). The result, as described by AbouZahr and Boerma (2005, p. 581) is *"[...] separate and parallel mechanisms that respond to donor requirements rather than to the needs of country decision-makers".* This fragmentation might greatly affect the ability to make all relevant information available to decision-makers. Further, as each vertical reporting regime often implement their own collection tools, the health workers and data reporting personnel are left with a variety of different computer and paper-based forms with different layouts for reporting (Lippeveld et al., 2000).

Integration

Standards are a vital component of information systems (Hanseth, Monteiro, & Hatling, 1996). To exchange information between people, organizations, and systems, consensus on why, what, and how to transfer information needs to be established. In large systems with no explicit authority to enforce such standards, this is a complex process which involves agreement on both technical, organizational and political level (Braa & Sahay, 2012a, p. 67). Integrating vertical reporting regimes is therefore to a large extent a process of standardization. To enable data exchange and integrated information systems, common standards for software, communication protocols, and what data that is to be collected and shared has to be established. (Braa et al., 2007; Chilundo & Aanestad, 2005). Dealing with a fragmented, mostly donor-driven health system, consisting of a variety of autonomous organizations, this process is associated with significant complexity by requiring agreement between the involved actors (Sæbø et al., 2011).

Top-down approaches to standardization have thus proven difficult in such heterogeneous and complex organizational conditions (Nielsen & Sæbø, 2016). With no single governing body, alignment of actor interests, information needs, and development of complete requirements for common systems in advance of systems development is practically impossible. Based on several years of HMIS standardization attempts in developing countries through the HISP project, Braa et al. (2007) have proposed a bottom-up approach, referred to as the *Flexible standards strategy*. The approach to standardization is theoretically based on concepts from Complexity Science and Complex Adaptive Systems theory (CAS) (Sæbø et al., 2011). Central is the concept of attractors, which are components of a complex system that exhibit some characteristics that create stability and a new order in the overall system. From an information systems perspective, an attractor could be a piece of software or a defined set of standards that over time emerge as a desirable alternative to existing regimes and hence develop into a common standard. This process unfolds through self-reinforcing network effects of adaption, increased value, and increased credibility of the standard. When a software or standard is introduced, desirable features could attract further adoption. Increased use will both increase the credibility to, and value of adapting it for other actors (Figure 3-1).

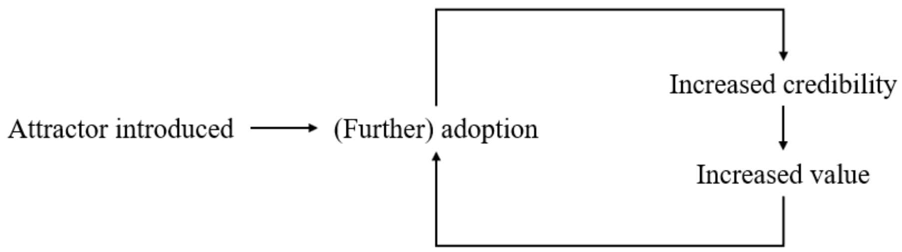


Figure 3-1 The self-reinforcing network effect of an attractor (adapted from Ciborra, 2000)

Examples of such attractors are Microsoft Word or the Microsoft Windows platform, which both have emerged as de-facto standards for document processing and desktop operating systems through a self-reinforcing process of adoption. Braa et al. (2007) illustrate how this effect can be used as an advantage to introduce common standards in the fragmented field of HIS in developing countries. In South Africa, the successful implementation of a standard minimum data set, and the DHIS software that supported collection, processing, and presentation of such information created an attractor that promoted adoption by other health programs and reporting regimes. As adoption increased, new actors saw the standard as an attractive alternative to their existing regimes, and gradually, the solution emerged into a common national standard. Similar approaches have been attempted in several other countries with relative success (Sæbø et al., 2011).

Other literature describing bottom-up standardization initiatives based on the concept of attractors (e.g., Hanseth and Aanestad (2003); Hanseth and Lyytinen (2010)) argue that immediate usefulness and end-user acceptance is a key driver of such processes. In the following section, we will see that such acceptance can be related to data entry interfaces.

3.2.2 Poor Data Quality and Issues with Timeliness

Lippeveld (2001, p. 1) argues that one guiding principle for HIS strengthening is *"to improve data collection procedures, data transmission, data analysis, and data presentation to generate quality and timely information"*. Hence, in addition to a fragmented field of reporting regimes, low data quality and timeliness poses a significant challenge to HIS in developing countries.

This might be a result of many factors, such as how data is transported to the higher levels, how data collection tools are designed, low motivation for data reporting at the point of data entry, and, as mentioned, due to fragmentation in data reporting to several health programs.

Data transportation

While HIS gets increasingly computer-based, also at the levels of data collection, a high percentage of facilities still lack network coverage and computers. This implies that data collection need to be supported on both paper and computer and that transportation of paper forms needs to be carried out, a process which might have an impact on timeliness. Transportation of paper forms is often solved by the pragmatic use of available resources, such as motorbikes, or collaboration with established transportation systems in the local area (e.g., see VillageReach (2012)). Further, to make use of data from paper forms in computerized HIS, a frequent practice is to implement paper-to-computer gateways at strategic levels of the health system, where computers and internet connection are available. Personnel here enter data from paper into a computer system on behalf of other facilities. As these users may perform this activity for several hours at the time, the transition of data from paper to computer is often prone to entry errors. This makes the layout of these data entry interfaces and training of personnel in charge of the data entering an important aspect (Braa & Sahay, 2012a, p. 64).

Data collection tools

Data collection is performed by various types of health personnel, often at the lower levels of the health system, or at the paper-to-computer gateways. Lippeveld et al. (2000) use the term *Collection instruments* to describe tools for data collection in HIS. These instruments or tools exist in different forms such as paper forms, checklists, or computer software, and their design is argued to be of great significance to data quality.

"The quality and ultimate use of the data collected through routine information systems will depend substantially on the relevance, simplicity and layout of the data collection instruments." (Lippeveld et al., 2000, p. 95).

The health workers that use these tools are often more concerned with clinical tasks such as patient treatment, thus data reporting becomes an additional task. Moreover, as fragmentation results in several program-specific forms with different layouts, this is a resource-intensive process, and with limited time and motivation to perform the actual reporting, data quality might suffer (Mosse & Sahay, 2005). AbouZahr and Boerma (2005, p. 581) articulate this as a primary challenge in that *"the assumption seems to be that health-care workers can take on the duties of health information officers. Yet providers are understandably reluctant to divert their attention from patient care to data recording."* Simultaneously, resources for training is limited, and prior experience with computer-based systems is often minimal or non-existing (AbouZahr & Boerma, 2005; Lippeveld et al., 2000).

Based on this, Lippeveld et al. (2000) argue that the *burden* (the time and effort needed to fill in data in the instrument), *layout* (how data entry elements are presented in entry forms), and *clarity* (ease of use, and clear instructions) of the tool are essential factors to ensure data quality, and should be emphasized during design. These layouts should thus be designed to provide clarity to the particular health workers that will use them and to minimize the burden associated with data entry.

In this thesis, the main concern is data collection tools provided by computer software. In line with Lippeveld et al.'s (2000) emphasis on data collection tool design, the problem of designing digital systems and interfaces that suit particular user groups and domains is a well-established phenomenon within the broader field of information systems research. In the following sections, literature that explore this general challenge, and user participation in design to address this, is presented.

3.3 Ensuring Fit between Technology and Use

ICTs are getting widespread in developing countries, and data collection tools in HIS are increasingly implemented as digital data entry interfaces (Sæbø et al., 2011). This might further reinforce the issue of creating data collection tools with layouts that provide clarity to local health workers.

Software used, are built and designed by computer specialists rather than people with knowledge of the work domain, context, and routines (Heeks, 2002). They are further often developed by international software providers that promote their systems to support a variety of use-cases and organizational contexts. In these cases, technological solutions are either transferred from a developed country to a developing country context, between different developing countries or from use in one domain (e.g., health management) to another (e.g., logistics management or patient follow up). Discussing the high rate of failure in information systems development and implementation in developing countries, Heeks (2002) introduces the notion of 'design–actuality gaps' to illustrate an issue that emerges due to the difference between the design of information systems components and the context where it is implemented. The author discusses how the designers inscribe both their own cultural background and presumption about the context of the final users into the technologies being developed. This may vary significantly from the actual context, hence creating a gap between design and actuality. The greater the gap, the greater the chance of project failure. What Heeks (2002) and other scholars such as Suchman (1993) argues is that information systems design needs to pay attention to particularities to the specific context of use, hence, *"[...] design has to be understood as 'artful integration' rather than 'design from nowhere'"* (Rönkkö, Hellman, & Dittrich, 2008, p. 71).

Digital interfaces, combined with a user group with limited or non-existing experiences with the use of computers, makes communication between software developers and end-users relevant to ensure this 'artful integration' rather than 'design from nowhere'. Regarding both paper-based and digital data collection tools, Lippeveld et al. (2000, p. 108) argue that engaging health workers, that is, the future users of the collection tools in design, is a mean of ensuring clarity in the layout to avoid the type of gaps that Heeks (2002) discuss.

"Forms design is a multistep, iterative process. Pretesting is an absolute necessity before finalizing the design." Lippeveld et al. (2000, p. 108)

With *pretesting*, the authors refer to evaluating the design with potential users before implementation. Extensive focus on user testing is justified by avoiding issues in layouts that might affect data quality. However, the authors do not discuss *how* user participation in the design of such tools can be executed. To explore this, the following section will present literature related user involvement in information systems design.

3.3.1 User Involvement in Design

Issues introduced as a result of 'gaps' (Heeks, 2002) or misfits (Gasser, 1986) between computer systems and established work routines in organizations has been discussed extensively the last decades. In line with Lippeveld et al.'s (2000) emphasis on iterative pretesting in data collection tool design, user participation in the design of new computerized systems has been increasingly recognized as an essential measure to ensure that systems integrate well with established work practice. Based on findings from several studies, Damodaran (1996) argue that involving users in design can be beneficial in building systems of higher quality due to more informed requirements, avoiding irrelevant functionality, increasing system acceptance, improving the users understanding of the system, and increasing participation in decision-making. With such benefits, the involvement of users in design has emerged as an integrated part of software development in Scandinavian and other western countries, to ensure better-suited systems and user interfaces in all types of information systems, from commercial products to government websites.

Participation or involvement may, however, come in different forms. Damodaran (1996) characterizes involvement on a continuum from informative, where users only provide and/or receive information relevant to design and technology, consultative, where users provide comments on predefined alternatives, or participative, where the user's influence decisions regarding all aspects of the system (Figure 3-2). This thesis uses the term user participation and user involvement interchangeably, in both cases referring to *"the involvement of users in work activities during system development"* which aims at *"involving future users of a computer-based system in decisions during system development"* (Bjerknes & Bratteteig, 1995, p. 73). This definition of user participation emphasizes users as active participants in decisions, and thus fall somewhere close to the participative end of the continuum.

A variety of methods for user involvement in information systems design have been defined and discussed in the research literature. Kujala (2003) outline four major approaches: User-centered Design, Participatory Design, Ethnography, and Contextual Design. Common is the objective to ensure a better fit between technology and use. Other underlying motivations, the level of user engagement, and the methods of engagement used vary, placing them differently on the continuum of involvement.

Informative	**Consultative**	**Participative**
Users provide and/or receive information	Users comment on a predefined service or range of facilities	Users influence decisions relating to the whole system

Figure 3-2 Forms of user involvement (Damodaran, 1996, p. 365)

Participatory Design

The Participatory Design (PD) approach to user involvement has influenced the HISP project (Braa & Sahay, 2012b) and the research of this thesis more specifically. PD emerged through research projects in Scandinavia in the late 70's and early 80's. Cooperating with labor movements, essential goals for researchers was to democratize decision-making regarding technology in the workplace, and ensure that workers, the actual users of this new technology, had a say in development and implementation. As new computers were introduced in the workplace, researchers and workers argued that these systems mainly provided management with innovative ways to exercise control and that too little emphasis was made on improving working conditions (Kensing & Blomberg, 1998). While Lippeveld et al.'s (2000) rationale for involving health workers when designing data collection tools is rather practical, important goals in the PD tradition have thus been to increase work satisfaction and acceptance for new technology, and to strengthen the workplace democracy by providing workers with the opportunity to participate in critical technological decisions affecting their work (Bjerknes & Bratteteig, 1995). PD hence focuses explicitly on the goal of engaging users in fundamental decision-making, which places it on the participative end of the continuum of involvement (Kujala, 2003).

The scope of PD projects may however vary. Gärtner and Wagner (1996, p. 195) distinguish between three arenas (A, B and C) of participation, defined by the desired project outcome, and which actors that are involved in the participatory process (summarized in Table 3-1). Arena A is project specific and concerns the design of particular systems and creation of new organizational forms. Arena B regards organizational change where *"Stable patterns of functioning related to participation are questioned and redesigned"*. Arena C is defined by an aim of national impact in that *"General legal and political framework is negotiated, which defines the relations between the various industrial partners and sets norms for a full range of work-related issues"*.

Table 3-1 Arenas for participation in PD (Gärtner & Wagner, 1996)

Arena	Level	Description
A	Project specific	Specific systems designed, and organization changed.
B	Organization	Stable patterns of functioning questioned and redesigned.
C	National	General legal and political framework is negotiated.

According to Gärtner and Wagner (1996), in a PD project, the focus can be on one or several of these areas. In the early PD initiatives during the 70s and 80s, the focus was often on change in all arenas. Projects aimed to impact concrete work situation, overall organizational mechanisms for participation, and national legal legislation and frameworks. Later, we see examples of a narrower focus, mostly concerning the specific system in arena A (Kensing & Blomberg, 1998), and greater involvement in organizational settings with focus on users, rather than the focus on unions and workers seen in the earlier projects (Clement & Van den Besselaar, 1993). The HISP project, which as described in chapter 2 are explicitly rooted in the PD tradition by empowering workers to take part in decisions, have focused mainly on arena A and B by involving users in specific HIS implementation projects, and by building more sustainable structures to support further participation in the future (Braa & Sahay, 2012b).

Enabling Participation

In all cases of the aim of impact, in line with the underlying idea of democratization, PD emphasizes user participation throughout the whole development process, from problem definition, idea generation and decisions on specific design elements and implementation. As with other approaches to user participation, PD projects are related to a set of methods and techniques to engage users. For PD, this typically includes workshops, focus groups, ethnographic methods such as interviews and participant observation, prototyping, and building of scenarios (Bratteteig, Bødker, Dittrich, Mogensen, & Simonsen, 2012; Kyng, 1994). To enable actual participation from end-users has however proved to be a challenging process, especially when attempting to involve users in major decisions (Damodaran, 1996). Based on PD's emphasis on ensuring that participants are invited to take part in fundamental decisions, Kensing (1983, p. 223) introduce three basic requirements for participatory design projects. These are of relevance to this thesis as they might be enabled and constrained by both organizational and technical factors. The requirements are:

(1) access to relevant information
(2) the possibility of taking an independent position on the problems
(3) participation in decision making

These requirements illustrate that participants need to be informed about possibilities and constraints that lies in technological solutions and organizational arrangements, and further that the involved organizations need to provide autonomy to the participants to be able to impact important decisions. Based on a review of ten PD projects, Clement and Van den Besselaar (1993, p. 31) added two additional requirements:

(4) the availability of appropriate participatory development methods
(5) room for alternative technical and/or organizational arrangements

Requirement 4 indicates that the project context needs to enable the use of participatory methods. Requirement 2 and 5 indicate that both technology and organization need to be flexible for change based on user participation. This flexibility and competence seem to be increasingly relevant when working with generic software packages, where major parts of the system have been designed in advance (Dittrich, 2014). We turn to the challenge of user participation and generic software in the following section.

3.4 Flexibility for User Involvement in Generic Software

The five requirements for user participation in organizations outlined in the previous section provides some pointers to what is required to enable spaces for user participation, and participatory design more specifically. However, the object of study in this thesis is data entry interfaces in generic software packages used in HIS. Being generic, that is *"systems designed for general use, as opposed to custom systems, designed for a specific user or group of users"* (Bansler & Havn, 1994, p. 708), the software and interfaces are pre-designed to support general use, and to be implemented in a variety of domains and contexts. This challenge the traditional emphasis on involving local users in early (or any) decisions, as the pre-designed software may constrain the ability to allow participants ‘the possibility of taking an independent position on the problems’, and to provide ‘room for alternative technical and/or organizational arrangements.’

Often, these software packages originate from one organization's needs and are later made generic to support similar use cases in other contexts (i.e., see Pollock and Williams (2009)). The differences in use cases and work settings provides challenges in ensuring that systems’ designs are well suited for specific work situations (Roland et al., 2017; Rolland & Monteiro, 2002) As described by Bansler and Havn (1994, p. 709) the designers of such systems *“must try to create a product with a kind of ideal-type functionality and user interface, designed for an ideal-type organization. This is a difficult task because such organizations don’t exist.”*

Fischer (2008, p. 368) discusses the tradeoff between generality, which is desirable because the system can be used across contexts, and specificity to support domain-specific and local use. On overly generic systems the author comments “*These environments are based on a level of representation that is too far removed from the conceptual world of knowledge workers in specific domains. They emphasize objective computability (i.e., what can be computed in principle), but they pay little attention to subjective computability (i.e., what can people do with a reasonable amount of effort and with limited knowledge about the computational environment).”* On the other hand, overly domain and use-context specific systems that *“are fitted very closely to specific tasks and will be difficult to use for anything outside the narrow scope for which they were designed. Modifying these systems to do things differently than the way provided leads to frustration and abandonment.”*

As briefly discussed, this is highly relevant to HMIS and LMIS in developing countries where generic software packages, such as DHIS2 (see chapter 2), Open LMIS (OpenLMIS, 2017), and ERP-systems (IFS, 2017; SageUK, 2017) are implemented to serve use cases across various countries, local contexts and domains. For example, Titlestad et al. (2009) describe how the DHIS2 software and the HISP project have expanded from national HMIS in South Africa, to a variety of countries in the Global South. Moreover, Nielsen and Sæbø (2016) discuss how the same software has evolved from supporting only health management information, into other health-related domains, such as patient follow-up systems and health logistics management. As we saw in the first section of this chapter, each of these domains and use contexts will imply different requirements to system design, including the design of data entry interfaces.

A balance between the ‘overly generic’ and ‘overy specific’ thus need to be found. Based on this issue, an array of iterature argue that generic systems can support specific local requirements and integrate well with existing work by providing flexibility for local customization (Baldwin & Woodard, 2008; Fischer, 2008; Roland et al., 2017) through some *"mechanisms for their users to adapt the software to a specific application context"* (Dittrich, 2014, p. 1443). Customization in this context means *"that the intended users [or local developers] change the system design in order to reflect their work practices and needs"* (Kimaro & Titlestad, 2008, p. 2).

Fischer (2008) argues that this can be achieved by designing such software as *open systems* through what the author term *meta-design.* Dittrich (2014) provides a similar argument, in that *"The delivered product is rather a half product that has to be configured and customised to a specific context".* According to Fischer, such meta-design is performed by *"creating spaces in which users as developers and designers can create their own solutions to fit their needs."* (Fischer, 2008, p. 370). It is further argued that these *spaces* are reliant on both flexible technical infrastructures and social infrastructures.

"The meta-design approach strives at creating not only a flexible technical basis for design, but also social infrastructures in which users can participate actively as co-designers to shape and reshape socio-technical systems." (Titlestad et al., 2009, p. 6)

This flexible space thus allows customization of the generic software. This is in line with Bansler and Havn (1994, p. 710), which use the term 'configuration development' to describe the design process that unfolds during the implementation of pre-designed generic software. Such flexible spaces are therefore instrumental in enabling local users to participate in decisions regarding design, by allowing them independent positions to problems, and alternative technical arrangements as outlined by Kensing (1983) and Clement and Van den Besselaar (1993). The following sections will explore such technical and organizational enablers of flexibility and 'space' for participation in detail.

3.4.1 Flexible Platforms to Provide *Space* for User Involvement

Bansler and Havn (1994) argue that there are four ways to implement a generic software into an organization: 1) No tailoring were the users must fully adapt to the software, rather than being designed to support local routines. 2) Installed with some tailoring through options already available in the generic system. 3) Custom tailoring, where the software is more extensively customized to organizational needs. 4) By providing the software as an open system including programming tools available for implementers to customize the system independently. As Lippeveld et al. (2000) argue that a process similar to the first strategy might result in misfits that impact data quality in HIS, one of the three last strategies seems beneficial, where the data collection tools are adapted to the users, and not the other way around.

In line with Bansler and Havn (1994), to enable these strategies of implementation, Fischer (2008) points at several technical measures to provide flexibility for customization and tailoring, such as built-in modification and customization options, and plugin structures for extension of functionality. He further argues that for a fully open system, modular architectures providing Application Programming Interfaces (APIs), or, open software source code, can enable full flexibility for local implementers.

Roland et al. (2017) argue that platform architectures can address critical issues related to this balance between global generic functionality and local requirements in information systems by entailing the flexible characteristics described by Fischer (2008). The architectural model of platforms founds the basis of an increasing array of software products from providers such as Microsoft, Google, and Facebook (Plantin, Lagoze, Edwards, & Sandvig, 2016). The technical architecture of a platform consists of three components: core components with limited variability, complementary components with high variability, and interfaces that enable communication between them (Baldwin & Woodard, 2008). Often this is modeled as a structure where a generic 'core' provide the included functionality and interfaces that enable development of the complementary components as loosely coupled modules, often called apps or third-party apps (Tiwana, 2013). These apps can be developed to provide additional functionality and more context-specific design.

Platform architectures may come in different forms, but typical is the generic core and outer layers of flexibility to customize and add functionality. Figure 3-3 provides a simple illustration of a three-layered technical platform architecture. The platform core is generic and shared between all instances of the system. Built-in tools (often referred to as *bundled apps*) are provided as a part of the generic package and provide flexibility to select and customize relevant built-in/core functionality. The outer layer provides the flexibility to develop additional apps that provide specific functionality and user interfaces that are tailored to the domain, use and context. These apps often communicate with the platform core and other components through a standardized API (Tiwana, 2013).

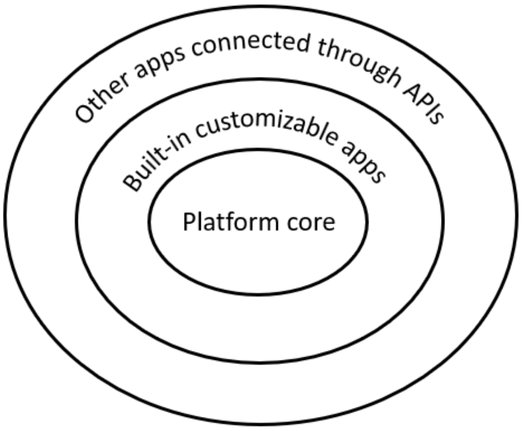


Figure 3-3 Simple illustration of a platform architecture

Roland et al. (2017), Titlestad et al. (2009), and Kimaro and Titlestad (2008) argue that the platform architecture of the DHIS2 software and the distributed nature of the HISP project provide this *space* for user participation and customization, which enables DHIS2 to be successfully implemented in a variety of domains, use-cases, and contexts.

3.4.2 Social Architectures to Provide *Space* for User Involvement

Flexible system architectures, such as platforms provide a foundation for *space*. However, Fischer (2008) emphasize the role of the social architecture in ensuring space for participation in that support mechanisms need to be in place to enable utilization of technical flexibility. Platform literature often uses the term 'ecosystem' to describe the relation between technical platform architectures and the social environment that surrounds it. In the words of Dittrich (2014), ecosystems are being used to *"[...] describe software developed, maintained and evolved through collaboration of the software product developer and 3rd party developers."* Together, the platform core, its modules, and the surrounding social architecture form a socio-technical ecosystem, that is argued to be capable of adapting to changes in use and environment (Baldwin & Woodard, 2008). In addition to layered technical architectures as described, these socio-technical structures or 'ecosystems' should provide mechanisms for cross-implementation communication, competence building, and sharing of requirements and experiences (Fischer, 2008).

According to Dittrich (2014, p. 1443), essential characteristics of generic software projects are that design of different implementations is distributed between several organizations and constituencies, and that technical architectures are built to support this design distribution. Thus, the mechanisms implemented in the social architecture have two functions: 1) enable utilization of technical flexibility in local implementations, and 2) feed experiences and requirements from local implementations back to the ‘core’ developers to provide the basis for further development of the generic software package. Hence, the ecosystem should provide mechanisms for this two-way communication where local domain and developer competence is needed to tailor the system in the relevant context, and the *“results of adaptations and ‘design in use’ are through the ecosystem fed back into the main development organization”* (Dittrich, 2014, p. 1443). An illustration of this process is provided in Figure 3-4. The circle surrounding the customizable software illustrate the space that is created by a flexible technical architecture and the social architecture of competence and sharing.

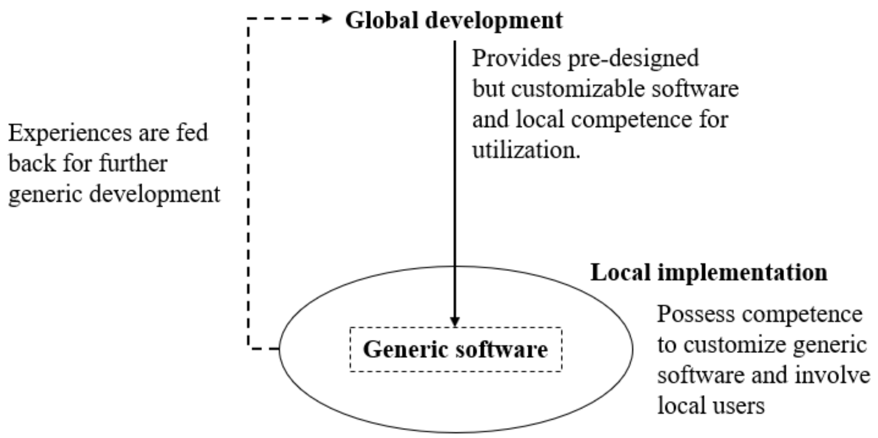


Figure 3-4 Social architecture providing space for participation

In this way, user participation in design can provide learnings of users, contexts, and domains that serve the local implementation, and the global development (Roland et al., 2017). Dittrich (2014) provides an example from how Microsoft distributes and maintain their ERP application *Dynamics* through a network of so-called partners. These partner companies sell the product to customer organizations and customize it to their specific needs. Here, basic configuration is enabled by the software package with built-in tools, while more extensive customization is available in a developer environment where code can be changed and added. These partners are in contact with end-users during design and development to configure and customize the software based on local needs. Further, the networks of partners communicate experiences and requirements from their implementation projects back to the core developers at Microsoft, enabling further development based on the user needs to be captured throughout the network.

Another example from such bi-directional sharing mechanisms is provided by Titlestad et al. (2009) in the HISP project from an implementation effort in India. Here, competence in implementation and development of the DHIS2 was established locally, providing local consultants with autonomy to customize and develop the software based on local requirements.

The open source software license enabled local implementers in India to extend the functionality of the system core to provide decision-makers customized 'dashboards' with visualization of key health indicators – a requirement that emerged from local needs. Experiences were communicated to the 'core' development team of DHIS2, and the functionality was later implemented as a standard part of the software package.

Social Architectures as Scaffolding

Titlestad et al. (2009) draw upon the concept of scaffolding to illustrate how these social mechanisms work in the HISP project. Just as construction workers use temporary scaffolding when building a house, a supporting infrastructure need to be built to enable the activities of the systems design process. That is, in the words of Orlikowski (2006, p. 462) *"[...] for the duration of a particular human practice, actors draw on various artifacts, spaces, and infrastructures to conduct their activities"*. This scaffolded infrastructure supports developers and designers throughout the design process, enabling communication of local requirements and technical possibilities and constraints between various actors.

However, in contrast to building a house, Titlestad et al. (2009, p. 20) argue that to enable continuous user participation in an constantly evolving generic software system, *"such efforts must be durable to have real impact, and therefore, this kind of scaffolding must be relatively permanent [...] and involve institutionalisation"*. As these scaffolds institutionalize into permanent structures, the result will be social infrastructures entailing mechanisms that support further local development and implementation. This establishment of more or less permanent support structures is argued to be one mean of meta-design to create an social infrastructure for user participation (Fischer, 2008; Titlestad et al., 2009).

The scaffolding strategy is manifested in the HISP project through their distributed development model described in chapter 2. Through new implementation initiatives, social support structures are built locally in countries of implementation, and mechanisms for communication between local nodes and global development are established and maintained through email lists, workshops, and other fora. When the particular implementation project has ended, the scaffolding structures are still preserved to promote further implementation. In turn, these local implementation nodes feed experiences back to the HISP network, sharing use-cases and best-practice to other nodes, and the core developers. In relation to Gärtner and Wagner (1996, p. 195) 'arenas' to affect with PD, this scaffolding process thus support user participation to affect specific implementation projects (arena A), and the structure itself is addressing arena B, where overall organizational mechanisms for participation are affected.

Boundary Spanning

Within these scaffolding, local implementation projects become mediators of requirements for further development of the generic software core. Moreover, as projects such as HISP and DHIS2 are engaged in multiple sites and dimensions, communicating requirements between a variety of actors, boundaries between these needs to be bridged. Titlestad et al. (2009) use the notion of boundary spanners to describe *"persons who act as mediators, traversing boundaries between organisations and teams, enhancing informal communication across networks" (Titlestad et al., 2009, p. 6).* These need to possess competencies, credibility, and legitimacy in the different areas they span. Examples of such areas are local development and implementation initiatives, the global development project, and users and managers of the organization that are to use the software. Hence, the vital role of boundary spanners is to bridge communication between involved actors and are therefore essential parts of the social support structure.

Figure 3-5 illustrates how local 'implementers' as boundary spanners function as a mediator between global and local developers, and managers within the health domain in the HISP project. An implementer is often a person within the local node that oversee the development process but might also be directly engaged in concrete software development tasks. Further, this person will be central to communicating with health experts, managers, and local end-users.

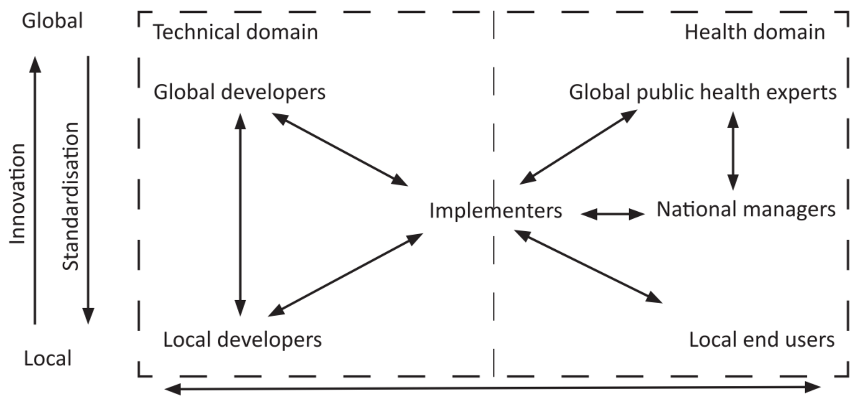


Figure 3-5 Implementers as boundary spanners (Titlestad et al., 2009, p. 18)

According to Titlestad et al. (2009), boundary spanners as mediators between actors, enabled by a social scaffolding of local competence and mechanisms for communication, is essential to utilize technical flexibility provided by the platform architecture. They further argue that the DHIS2 software itself serves as a part of this scaffolding by providing the local implementers with a pre-defined tool for prototyping and requirement communication throughout the development process.

"The platform-like character of the software means that it is simultaneously part of an end product which includes reports and local data standards, as well as scaffolding used by boundary spanners in collaboration with local users to make systems function in their work settings." (Titlestad et al., 2009, p. 18)

To summarize, user participation when implementing generic software packages is argued to be enabled by flexible software architectures that allow developers to customize user interfaces and other components to suit local requirements. To support this, a social architecture of competence and experience-sharing is instrumental to the utilization of this technical flexibility. As the case of this thesis further concerns a project in Uganda, which might provide a different cultural and political context than where participatory methods of design originate, literature discussing the contextuality of user involvement will be explored in the final section of this chapter.

3.5 Contextuality of User Involvement

As discussed by Kensing (1983) and Clement and Van den Besselaar (1993), there are several requirements that a user organization need to support to enable end-users and workers to participate in actual decision-making regarding design. Software development and implementation in developing countries such as Uganda provide a different cultural context than where participatory methods and techniques to information systems design originate from. A body of literature suggests that application in developing country contexts poses somewhat different challenges related to socio-economic factors. For example, based on three cases of user participation in design of information systems in South Africa, Mozambique and India, Puri, Byrne, Nhampossa, and Quraishi (2004, p. 49) argues that *"Cultural practices are deeply embedded in the ethos of the community, and the participatory paradigm in these settings is bounded by the cultural traditions and practices."*. With this, it is argued that cultural aspects of organizations and communities can both constrain and enable the space for user participation. For example, strong hierarchical cultures pose challenges in fostering true participation, and mediating agencies such as universities might play a crucial role as mediators or *boundary spanners* to enable acceptance of participatory approaches. The authors emphasize the contextual nature of participation, in that *"there is no single algorithmic best practice regarding participatory design in information systems which is applicable to all situations"* (Puri et al., 2004, p. 42). Sæbø and Titlestad (2004)s reports similar challenges from a HISP implementation project in Cuba, where a strongly centralized governance model in the public health sector required the methods for participation to be adapted.

Thus, the process of scaffolding a social architecture needs to adapt to local cultural conditions, and the boundary spanners play a central role in mediating activities to ensure that users are included in relevant activities (Titlestad et al., 2009).

Furthermore, participatory approaches to design emphasize a mutual learning process, where developers learn about the domain, and user participants learn about technical possibilities and constraints (Bjerknes & Bratteteig, 1995). As seen, 'access to relevant information' is outlined as a fundamental requirement for participation by Kensing (1983, p. 223). Kimaro and Titlestad (2008) discuss how limited prior experience to computer systems poses a problem to effective user participation. The lack of knowledge mystifies the design process, making participants contributions less informed. The authors argue that effective participation in such contexts require more concrete design suggestions through what they term 'participatory customization', that *"present the users with a pre-developed and flexible system that can easily be customized in collaboration with the developers"* (Kimaro & Titlestad, 2008, p. 6). These system prototypes should enable fast and easy changes to be able to present participants with options to the posed design suggestions and ideas. These corresponds to the built-in customization options discussed by Fischer (2008), where customization is performed with small changes in the system, often without the need of programming.

We now turn to a summary of the most relevant concepts presented in this chapter, what will be used during analysis and discussion of the empirical findings.

3.6 Summary of Concepts Relevant to the Analysis

In accordance with the aim of investigating enabling and constraining factors for user participation when designing a data entry interface in a generic software package, the literature and concepts presented in this chapter are related to 1) understanding information systems and HIS, 2) HIS challenges and strengthening in developing countries, 3) user participation in the design of information systems, 4) user participation in customization of generic software, and 5) the contextuality of user participation.

Central Concepts

This chapter has covered several concepts relevant to the analysis of results. These can roughly be divided into two categories: 1) concepts that help understand the problem of generic data entry interfaces in HIS, and 2) concepts that help understand how user participation is constrained and enabled in generic software implementation.

For the first category, we see that generic software packages used in HIS introduce digital data entry interfaces to health workers. These need to provide layouts with clarity to reduce the burden of use and promote data quality and timeliness (Lippeveld et al., 2000). If these are not designed with the health workers in mind, design-actuality gaps (Heeks, 2002) or misfits (Gasser, 1986) between design and established practice may occur. This may affect data quality, user satisfaction and their acceptance to new technology (Damodaran, 1996; Kujala, 2003). Figure 3-6 provides an illustration of HIS and the outlined concepts. Moreover, several parallel reporting regimes introduce fragmentation, that results in several data collection tools with different layouts (AbouZahr & Boerma, 2005). Bottom-up approaches to integration by using an 'attractor' is argued to be one way of promoting integration of these (Braa et al., 2007; Sæbø et al., 2011).

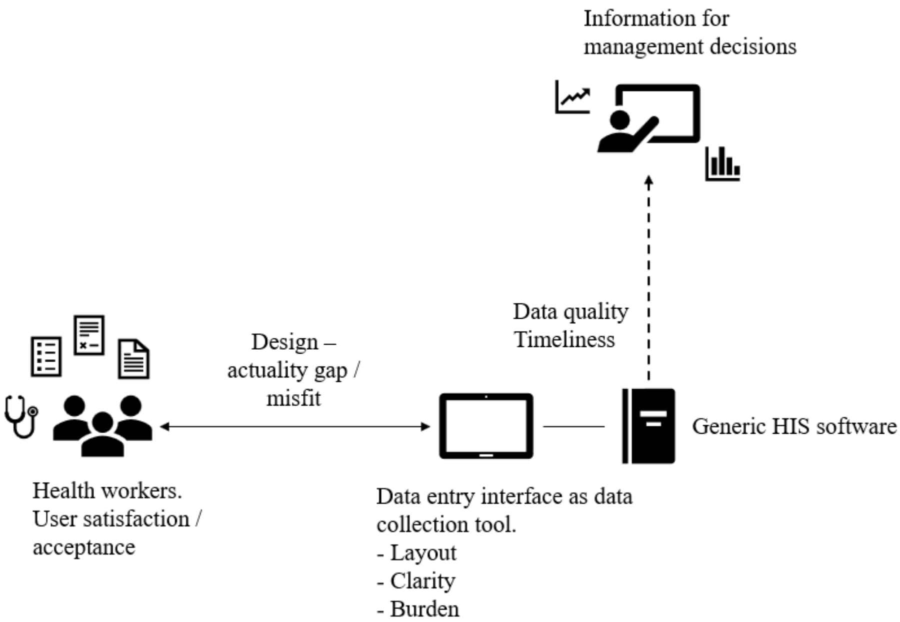


Figure 3-6 Concepts relevant to data entry interfaces

For the second category, it is argued that engaging users while designing layouts might increase clarity in collection tools (Lippeveld et al., 2000), and minimize gaps and misfits between use and technology (Kujala, 2003). User engagement or participation imply the involvement of users on a informative, consultative or participative level (Damodaran, 1996), and is generally enabled and constrained by several factors, for instance, the participant's ability to take an independent position to problems, and to what degree technical and organizational changes are allowed (Clement & Van den Besselaar, 1993). When using generic software, these interfaces are often pre-designed, which might put constraints on these factors (Bansler & Havn, 1994), and thus the possibility of creating layouts that fit health workers in a specific implementation.

It is, however, suggested that this can be enabled by creating socio-technical *spaces* for user participation through flexible technical and social architectures (Fischer, 2008). Technically this can be achieved by designing the software to support customization, for example through open source software licenses, modular architectures and APIs, or built-in configuration options. Platform architectures are built based on (some) of these principles and are argued to enable customization (Roland et al., 2017).

Socially, scaffolding can be built to support local utilization of technical flexibility through mechanisms for competence-building and sharing of experiences (Titlestad et al., 2009). Here, boundary spanners are important mediators that have proximity to local users, while entailing the competence to customize the software. Figure 3-7 illustrates the relationship between these concepts.

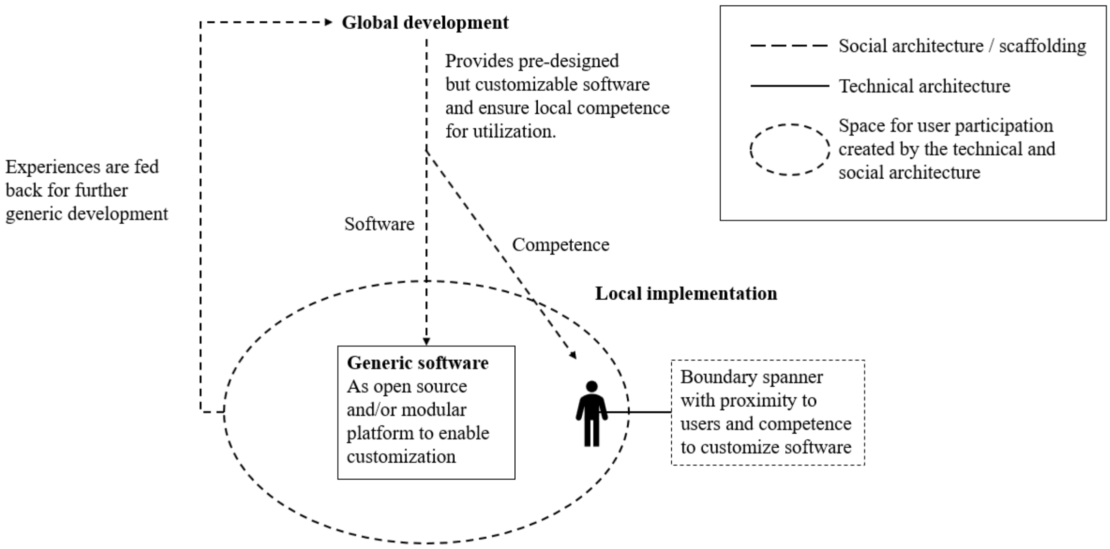


Figure 3-7 Concepts relevant to user participation in generic software implementation

Literature presented that discuss such spaces for participation mainly focus on this space on an abstract level, and how requirements from local implementations are fed back to the generic development process. As described in the introduction, this thesis will use these concepts to analyze and discuss this space from a more local implementation-oriented perspective. Before that, we now turn to the research approach of this thesis, outlining the methodology, methods, and techniques used to investigate and participate in the project in Uganda.

Chapter 4 - Methodology

The empirical basis of this thesis is an Action Research project that lasted for about two years, including three months of fieldwork in Uganda. This chapter will provide an account of the research methodology, methods, and techniques used in this research.

This research has been part of the HISP project and initially based on a research theme defined in cooperation with HISP Uganda of *strengthening the system for antiretroviral (ARV) related commodity ordering and reporting from hospitals and health clinics*. As the process unfolded the research question and objectives were defined and updated based on findings in the different stages. The final objectives are, as outlined in the introduction, to 1) investigate how the existing commodity ordering system and its data entry interface have been designed, and what role user participation played in this process, 2) to develop a new data entry interface trying to involve health workers and data entry personnel in design, and 3) to analyze these processes to identify relevant technical and organizational factors that enabled or constrained user participation. Objective 1 and 2 were addressed by investigating the existing system and how it was designed, and participating in further development. Objective 3 were addressed by discussing the process with involved actors, mainly HISP Uganda, and through a thematic analysis of the documented data.

In line with the research theme, an essential part of the research has been to do an intervention in the existing system. Based on this, Action Research was chosen as a methodology because 1) it is the overall approach within the HISP project, which my work in Uganda is part of and builds on, and 2) more importantly, because of its ability to generate knowledge of dynamic social systems embedded in organizations through interventions, benefiting both the client-system of focus, and the scientific community (Baskerville & Wood-Harper, 1996).

In the diagnostic phase of the Action Research project, the digital data entry interface implemented in the computer-based commodity ordering system was identified as a source of challenges. Guided by theory, a design process inspired by Participatory Design and the method of 'use-oriented design' (Bratteteig et al., 2012) was initiated as an intervention to develop a prototype to address the identified issues. As we see later in this chapter, both Action Research and use-oriented design are cyclic processes that consist of identifying problems, responding to these issues through some sort of intervention, and evaluating these. The research process will be presented as one single iteration of Action Research, with several iterations of use-oriented design in the action phase (see Figure 4-1). Arguably, it could also be presented as intervened cycles, where the use-oriented stages correspond to the diagnostic, planning and evaluation phase through several iterations. By using participatory approaches within an Action Research project, the research approach has similarities with participatory interventionist methodologies such as 'Participatory Action Research' (Baum, MacDougall, & Smith, 2006). These approaches, however, imply a stronger emphasis on critical ontological assumptions, on user participation when planning and negotiating the overall research process, and involving these users in all stages of the research. The research process in this project mostly included health-workers in separate stages through diagnosis, action, and evaluation, and it was not given that these would participate after the diagnostic phase. Moreover, as the participatory 'use-oriented' process itself was the intervention for change (described in detail in the following section), the chosen way of presentation provides the most accurate account of how the process unfolded.

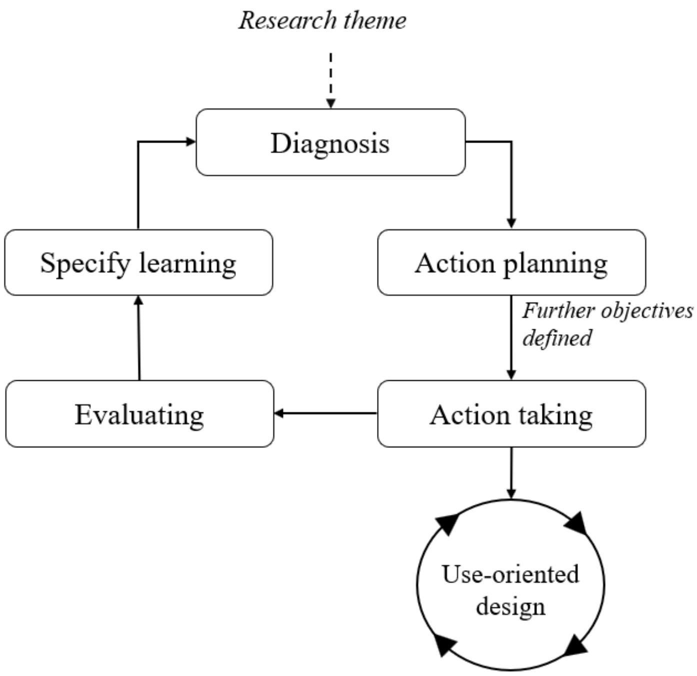


Figure 4-1 Research approach: Action Research cycle with use-oriented design

The rest of this chapter is structured in the following matter: First, a brief reflection on the philosophical foundation of this research and the application of Action Research is provided. Secondly, a detailed description of the data collection methods used in the diagnostic, action and evaluation phase will be outlined and described. Finally, methods of data analysis are presented.

4.1 Research Methodology: Action Research

This research has been interpretive (Klein & Myers, 1999; Walsham, 2006) in nature. To explore the research theme that initially guided this research process, investigation of, and intervention in a complex socio-technical system was required. Social systems and organizations are not static entities that can be objectively investigated and manipulated with controlled variables and replicable methods and techniques. In the words of Susman and Evered (1978, p. 596), (based on Heraclitus famous quote); *"you cannot step into the same social system twice"*. Hence, traditional positivist methods of scientific research are not well suited for investigating complex dynamic social phenomenon within organizations (Klein & Myers, 1999; Walsham, 1995). Firstly, these systems do not exist independently from human beings in that they *"obey laws that are affected by human purposes and actions."* (Susman & Evered, 1978, p. 584). They are tightly embedded within organizations, which are created by humans, consists of humans, and are designed and developed to support human activity. Hence, means and ends are to extent guided by values, rather than objective patterns. Secondly, they are planned according to expectations of the future, which is not aligned with the positivist interest in the investigation of clear patterns of cause and effect. In contrast to objects, humans entail the ability to self-reflect and discuss issues and challenges in the systems that they take part in. They also come with a history, which might substantially impact knowledge and action, both are factors that challenge the traditional investigation of cause and effect in controlled environments (Susman & Evered, 1978). Furthermore, different users, developers, implementers, organizations and other actors may have varying views, interpretations, and rationalities regarding objectives, functionality and future goals of such systems. Ontologically, it is hard to argue for one single objective truth to be discovered when analyzing such systems. As an epistemological stance, it is therefore natural to assume that knowledge of such systems must be derived from the interpretations and meanings that humans assign to them (Klein & Myers, 1999).

Although interpretive case studies (Walsham, 1995) are suited to investigate phenomenon in such complex multivariate environments, being non-interventionist they suffer from the lack of ability for intervention to study "the effects of specific alterations in systems development methodologies" (Baskerville & Wood-Harper, 1996, p. 240). Action Research, on the other hand, is a methodology that through an interventionist approach can be used to identify organizational issues, do interventions, and evaluate the outcome in cooperation between researchers and practitioners within a specific organization (Baskerville & Wood-Harper, 1996). The result of the intervention is evaluated to specify knowledge, which is of relevance both to the organization of study and to a more general field of research. According to Susman and Evered (1978), Action Research as a research methodology provides *"a mode of inquiry"* that are suited to investigate social systems with the dynamic properties described above. On the future agenda of research on ICTs and development, Walsham (2012, p. 90) argue that Action Research seem particularly suited to investigate *"complex new technologies, with hard-to-foresee consequences",* by *"design[ing] something and see how well it works.".* Rapoport (1970, p. 499) defines the aim as *"to contribute both to the practical concerns of people in an immediate problematic situation and to the goals of social science by joint collaboration within a mutually acceptable ethical framework".* It is further characterized by an actively involved researcher, expecting benefits for the researcher as well as the organization. Further, learnings should be of immediate usefulness, based on research that unfolds through a *"cyclic process, linking theory and practice"* (Baskerville & Wood-Harper, 1996, p. 239). Action Research is therefore well suited to address the objectives and investigate the intial research theme of this thesis.

Action Research may be viewed as a cyclic process of five stages (Susman & Evered, 1978). These stages are 1) a diagnosis of the existing systems and routines, 2) planning for action, 3) taking action to improve identified issue(s), 4) evaluating the outcome, and 5) specify the learnings. The researcher may be a part of one, several or all stages of this process (Chein, Cook, & Harding, 1948). For example, the researcher may take part in the diagnosis of the system of study (Diagnostic Action Research), or in diagnosing and action planning (Participant Action Research). In this research, the researcher has been highly involved in all stages, often referred to as Experimental Action Research.

Following is a brief description of the stages in the Action Research process, before the specific methods and techniques applied in the diagnostic, action, and evaluation phase is described in detail.

Establishing the research environment

Before the cyclic process is initiated, a *client-system* infrastructure or research environment, is established. This is where the mutual ethical framework is negotiated, and crucial aspects such as authority, and the scope of the research is negotiated (Baskerville & Wood-Harper, 1996). In the case of this research, the HISP project has already established an action research network, engaged in HIS strengthening in several countries in Africa. In Uganda, the project has established cooperation with the Ministry of Health through the local HISP node, HISP Uganda. The local organization has been conducting both consultancy services, and Action Research projects with the Ministry for several years. This includes development and implementation of the digital commodity ordering system in place which has been of focus in this study (described in detail in Chapter 5).

This means that a client-system infrastructure was already in place at the initiation of this specific research project. HISP Uganda had provided a pre-defined research theme, and in addition to this established agreement, the scope of this intervention, the included actors, and their respective obligations and responsibilities were negotiated for this specific project. Essential actors were HISP Uganda, the University of Oslo and Ministry of Health in Uganda.

Diagnosing

The Action Research cycle starts with a diagnostic phase, where the underlying issues are investigated to find opportunities for interventions, through a process of *"self-interpretation of the complex organizational problem, not through deduction and simplification, but rather in a holistic fashion"* (Baskerville & Wood-Harper, 1996, p. 238).

In this research, the diagnostic phase was conducted through a four-week field trip to Uganda in January 2016, where 1) an understanding of the information systems related to health commodity ordering were established, and 2) possible challenges were identified and explored. Through different methods such as document analysis, interviews, and observations, rich insight was gained on the status of the overall system, and on challenges to digital commodity ordering in one of the vertical health programs more specifically. Methods for data collection is described in detail in Section 3.2. Based on the challenges found, the research objectives were updated to address these.

Action planning

Knowledge gained from the diagnostic phase is used to identify opportunities for improvements. In the planning stage, organizational actions are discussed and specified, which are guided by theoretical frameworks and assumptions. Both the target for change and the approach to change is defined.

Literature on both HIS strengthening and on user participation in design guided decisions in the planning of intervention in this research. In the diagnostic phase, a digital data entry interface was identified as a possible source of issues in the commodity ordering system. As the issues seemed to be resulting from misfits between the computer system and the health workers' and data entry personnel's work routines, a participatory approach through use-oriented design (Bratteteig et al., 2012) was chosen as a method to attempt to design a more suited interface.

In short, three central assumptions derived from theory (presented in detail Chapter 3), guided the planning of action:

A. Data collection tools (i.e., digital data entry interfaces) are important to data quality and timeliness in HIS (Lippeveld et al., 2000).

B. Engaging users in the design of data collection tools can make a better fit between digital interfaces and existing work practices (e.g., Damodaran, 1996; Kujala, 2003).
C. The modular platform architecture of the generic DHIS2 software will provide the flexibility to enable customized design (Fischer, 2008; Kimaro & Titlestad, 2008; Roland et al., 2017; Titlestad et al., 2009).

Based on these theoretical assumptions it was argued that the challenges experienced in the data entry interface were important to the overall data quality of the information system and that these issues might be rooted in the approach to design and development of the interface. It was also argued that the software in use (DHIS2) would enable alternative approaches to design due to its technical flexibility. The planned action was to attempt a re-design of the interface (target to change), using a participatory approach where data entry personnel and other relevant actors were engaged in the process (approach to change). Here, I would be in charge of user involvement, and HISP Uganda was to contribute with valuable information on possibilities and constraints in the existing information system, and how the previous interface had been designed. The Ministry of Health helped plan new visits to relevant facilities to work with data entry personnel in designing a prototype for a new interface. To improve my understanding of the DHIS2 software, I also participated in a *DHIS2 academy* in Rwanda in August 2016 (Appendix 3). Over a duration of five days, technical aspects of the software were here taught in seminar form to a large group of developers and HIS implementers. These academies are further described in Chapter 5.

Action taking

In the action phase, researchers and practitioners implement the planned changes. In this research, the change lied in the nature of the design process of the data entry interface of the commodity ordering system. While the existing interface was developed through an expert-based approach, limited to including software developers and a domain expert from the Ministry of Health, the alternative process applied in the action-phase was a use-oriented approach, engaging a high number of end-users in the process. This was executed through an iterative process of requirement gathering, idea generation, prototyping, and evaluation. Methods and techniques of this process are described in detail in Section 3.3.

Evaluating

After the intervention, researchers and practitioners undertake an evaluation of outcomes. This includes *"whether the theoretical effects of the action were realized, and whether these effects relieved the problems"* (Baskerville & Wood-Harper, 1996, p. 238). In this research, it was evaluated whether the alternative development process (engagement of end-users in design, theoretical assumption B) had proven to ease any of the challenges experienced in the initial interface, and to what extent the DHIS2 platform and the organizational context had enabled and constrained this process (theoretical area C). This is further described in Section 3.4.

Specify learning

Focusing on solving immediate problems in the client-system, and contributing to the scientific community, the learnings from Action Research projects are aimed at several audiences. The learnings of this thesis are aimed at contributing to mainly the following three audiences:

1) The ministry of health on challenges with their existing system, and design suggestions in concrete prototypes for improvement. This can feed into new iterations of action inside the organization. For example, new master students are now engaged in further design and implementation of the new data entry interface.
2) HISP Uganda and the global HISP project on the design process. This includes user involvement in design (theoretical assumption B) and flexibility in the DHIS2 platform (assumption C).
3) The scientific community on HIS strengthening and user involvement in IS design with enabling and constraining factors for user participation under these particular conditions (this thesis, conference paper presented at IRIS17 (Appendix 2), and possible future research paper).

Following is a detailed description of methods and techniques used in 1) the diagnostic phase, 2) the action phase, and 3) in the evaluation phase.

4.2 Methods used in the Diagnostic Phase

As briefly described, the goal of the diagnostic phase was 1) for the me to establish a fundamental understanding of the process of health commodity ordering in Uganda, and 2) to identify possible challenges in the current information system.

In collaboration with two other master students doing research on other aspects of the supply chain (see Bergum, 2017; Hagen, 2017), the diagnosis was conducted during a four-week field trip to Uganda in January 2016. We worked closely with HISP Uganda, which arranged transportation and access through established contacts in the Ministry of Health. In total, eight facilities were visited, including two medium-sized, to large public hospitals, three private health clinics, one warehouse and one district health office. These facilities were located in two districts; Kampala and Soroti. Facilities were selected based on access, and with a goal to cover some of the diverse types of facilities existing in the country. While public health facilities were the primary objective, three private health clinics were visited for comparison.

4.2.1 Data collection methods

The study of each facility involved several types of qualitative methods for data collection:

1) Document analysis
2) Formal, informal and contextual interviews
3) Group discussions

The standard procedure when visiting a facility was to first do a document analysis of websites and other available material provided online or through the ministry of health. Then, information was discussed with representatives from the ministry of health and HISP Uganda. Formal and informal interviews were held at the facilities with personnel at the hospital pharmacy store, or other relevant departments at the site of inquiry. When appropriate, this also included a contextual interview. After the visit, my notes were discussed and compared with HISP Uganda and Ministry of Health. Table 4-1 lists number of facilities visited per type and district.

Table 4-1 List of facilities visited in the diagnostic phase

Type	Facilities visited	District
National referral hospitals	1	Kampala
Regional referral hospitals	1	Soroti
Medium-size public hospitals	2	Kampala, Soroti
Private health clinics	3	Soroti
Warehouses (JMS)	1	Kampala

Document analysis

The aim of the document analysis was to gain a basic understanding of the health facility before the visit. This typically started with general information about the district, the facility and its surroundings, which includes the number of beds and patients and social, economic and infrastructural conditions. Sources were online government documents, project reports, warehouse instruction sheets, or annual or quarterly reports produced by the Ministry of Health. This helped form the basis for interview guides used during the proceeding visit.

Interviews

Each visit was initiated by a prepared, semi-structured interview (Crang & Cook, 2007). Interview guides contained main topics of interest and some more concretely formulated questions. This to enable open-ended discussions allowing follow-up questions from both the interviewer and the participants. Present were the three master students, representatives from

HISP Uganda, and, on some occasions, the Ministry of Health. On some facilities, several health workers were interviewed, normally the head of the hospital pharmacy, and/or personnel in charge of commodity ordering and data entry into information systems related to logistics management.

As part of the interview, a contextual interview was held when appropriate. This was in the situations where logistics data entry personnel were present in their natural work environment. In these interviews, the participant was asked to illustrate how basic tasks, such as the bi-monthly ordering of HIV medicines were executed. While the participant demonstrated, he or she were asked to describe their activities, and follow-up questions were asked when necessary.

Group discussions

Between every visit, more or less formal group discussions were held with representatives from the Ministry of Health and HISP Uganda. This was arenas to clarify missing or unclear information and to discuss essential findings.

4.3 Methods used in the Action Phase

During the diagnostic phase, health workers identified and described challenges with the existing interface of the digital commodity ordering system for ARV related commodities (called WAOS). As an intervention, it was decided to develop a prototype for a new data entry interface. As mentioned, assumptions from theory guided the decision to involve data entry personnel and health workers at health clinics, hospitals, district health offices, and warehouses (N=41. See Table 4-4 for an overview). Participants both with and without experience with the existing digital interface of WAOS were included.

This section will provide an account of the participatory methods used in the action-taking part of the research project. As this process provides the basis of understanding enabling and constraining factors discussed in chapter 6, a detailed narrative of how the process unfolded is provided as results in Chapter 5.

4.3.1 Participatory Design

As seen in chapter 3, there exist several methodologies and methods for user involvement in information systems design (Kujala, 2003). These are mainly based on the idea that user engagement can promote usability, user satisfaction, and efficiency, and that this can be achieved through user evaluations and prototyping through several iterations. For instance, common approaches such as ‘User-centered design’ and ‘Interaction Design’ involves cyclic processes of establishing requirements, designing alternatives, prototyping, and evaluating with users (Rogers, Sharp, & Preece, 2011, p. 15).

While subscribing to this practical argument of building better systems that suit the users, the tradition of Participatory Design is further based on the critical perspective that user involvement is important as it promotes workplace democracy *"by giving the members of an organisation the right to participate in decisions that are likely to affect their work."* (Bjerknes & Bratteteig, 1995, p. 74).

This critical view founded the basis for user engagement when the HISP project was first initiated in post-apartheid South-Africa and is still an underlying philosophical assumption in the global project (Braa et al., 2004; Braa & Sahay, 2012b). The rationale for engaging users in design during the development process in the action phase of this thesis is mostly based on the practical argument of developing better systems. However, the fundamental idea of enabling health workers to have an impact on decisions on the design of technology that affect their work is an underlying motivation, both inherited from the overall HISP project, and as a personal philosophical stance.

"[…] computers were becoming yet another tool of management to exercise control over the workforce and that these new technologies were not being introduced to improve working conditions" (Kensing & Blomberg, 1998, p. 169)

As we will see in Chapter 5, the existing interface of WAOS had been developed by computer experts and health program managers, arguably with limited concern for the health workers. Similarities can be seen with the underlying motivation for the Scandinavian Participatory Design projects that subscribed to this principle of democratization summarized by Kensing & Blomberg (1998) in the preceding quote.

To address the issue of democratization, Participatory Design has a stronger emphasis on involving the participants in fundamental decision-making than the other methodologies mentioned. For example, 'User-centered Design' and 'Interaction Design' mainly include users when evaluating prototypes made by designers. These prototypes are based on requirements defined by the designer through investigations of user needs. In contrast, Participatory Design projects start with as little predefined conditions as possible to enable participants to take an active part in all decisions. Users are directly involved in defining problems and requirements, building prototypes, and discussing and evaluating these. To contribute with a practical solution that could be realistically implemented in the organization, a prerequisite in this project was that the interface developed had to be built in the DHIS2 software, and usable on the desktop computers already installed. However, apart from this, participants were provided with the opportunity to design the interface in any way within these relatively broad technical limits by starting with sketches on a blank paper piece of paper. As prototype fidelity increased, the designer took charge in the actual development of prototypes but involved users in every decision. The potential constraints introduced by the DHIS2 software will be part of the findings of this thesis.

Further, the issues identified in the diagnostic phase was also posed by health workers that later were included in the action phase, and the users were by this included in the definition of problems. These issues fed into the participatory process of the action phase and were further elaborated and explored by participants that already had been engaged in the diagnostic phase, and new participants from other health facilities.

The structure of the overall design process was inspired by a method of Participatory Design called Use-Oriented Design (Bratteteig et al., 2012, p. 127). As many other participatory approaches, the design process unfolds iteratively, where each iteration consists of (further) understanding work practice, identifying needs and wishes of the users, describing these as requirements, materializing these by prototyping, and then testing and evaluating them. The users should ideally be involved in all stages. Figure 4-2 provides an illustration of the use-oriented design process.

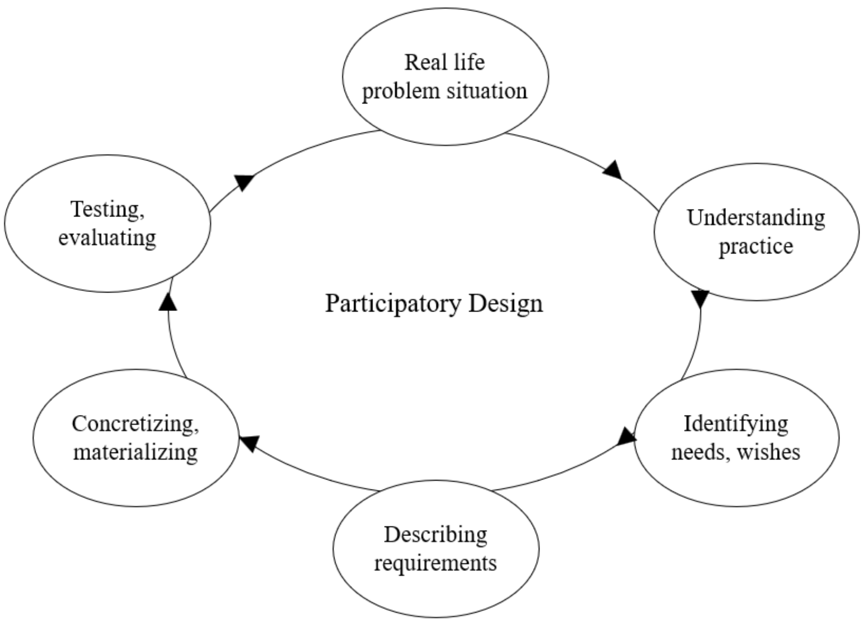


Figure 4-2 The participatory process of use-oriented design (Bratteteig et al., 2012)

As described by Bratteteig et al. (2012, p. 127), the emphasis is on the *use* rather than the specific *user. "It differs from user-oriented approaches by being concerned with the activities and logic of activities – the use – rather than the users."* The aim is to understand the activities of the variety of users to make the new design support future use. Following is a detailed account of this process.

4.3.2 The Process

The design process started in September 2016 and lasted for four weeks. Three key issues that were identified with the end-users in the diagnostic phase were used as a basis for initial requirements. Users representing the different user groups outlined in Table 4-3 were engaged, and several iterations of prototyping, discussions, and focus groups were conducted. As agreed upon, I was in charge of planning and facilitating all user engagements and development of high-fidelity prototypes. Representatives from HISP Uganda and Ministry of Health were also present at some of the evaluations and workshops. Another master student, exploring other issues in the supply chain, was also present at many of the meetings (see Hagen, 2017).

The process consisted of three major iterations, or phases, defined by aim and the techniques used. These are presented in Table 4-2. Each main iteration or phase encompassed several minor design-iterations of prototyping.

Table 4-2 The three major design phases in the use-oriented project

Phase	Description	User participation
Exploring ideas	Generate ideas, and using paper prototypes and index-cards to explore solutions to the main challenges with the existing interface	Discussions with data entry personnel at two health clinics, one district hospital and one representative from Ministry of Health.
Testing interaction	Using Wireframes and web-based prototype to test basic use of new interface	Testing with data entry personnel at one health clinic, one district health office, and one warehouse
Exploring details	Using paper and web-based prototype to explore additional ideas for improvement	Testing and discussions with experts at HISP Uganda, data entry personnel at one warehouse, one health clinic, the pharmacy department of Ministry of Health and CPHL.

Users

The end-users of the data entry interface are described as data entry personnel. They can be further divided into three groups of users, which are based on their frequency of use and experience with WAOS (summarized in Table 4-3). At the larger hospitals, these workers are only responsible for commodity management at the hospital store, while at smaller sites, such as health clinics, the people in charge of ordering and reporting also have the role as nurses and other patient-treatment related positions.

Table 4-3 Types of end-users included in the design process

Data entry personnel / Health workers	Description
At paper to computer gateways	Uses the data entry interface frequently to enter data from paper forms on behalf of several facilities.
At hospitals and clinics that already use WAOS	Uses the data entry interface once every two months to enter data.
At hospitals and clinics that do not use WAOS	Have not used the interface before, but might be enrolled in WAOS in the future

Also, biostatisticians and other personnel in charge of approval use the existing interface to look over orders and reports for their respective health facilities. Table 4-4 provides an overview of the number of participants engaged based on the facility type. It is important to emphasize that end-users were making the decisions regarding design, and that representatives from HISP Uganda and Ministry of Health mainly were engaged to follow and comment on the process. Moreover, HISP Uganda was essential in discussing technical possibilities and constraints, and how the current interface and system was designed.

Table 4-4 Summary of participants in the use-oriented design process

Who	Facilities visited	Participants
Data entry personnel at public health clinics (level 3)	2 (both revisited one time)	3
Personnel in charge of paper-based ordering at public health hospitals (level 4)	1	4
District health officers	2	2
Data entry personnel at warehouses	2	11
Representatives from HISP Uganda	-	6
Representatives from Ministry of Health	-	15
Total	7	41

Techniques for user engagement

Standard PD techniques (Kensing & Blomberg, 1998) were applied to engage and communicate with user participants, such as observations, interviews, focus groups, and discussions with data entry personnel at relevant facilities and offices. Paper sketches with ideas for new designs were drawn in cooperation with health workers based on the improved knowledge of established work, technical possibilities, and constraints. These prototypes formed the basis for more high-fidelity prototypes developed by me and were then presented and discussed with health workers to identify other issues and explore new ideas. A summary of prototyping techniques used is provided in Table 4-5. The process of prototyping, discussions, and evaluations was performed in several iterations, with increasing prototype fidelity. Figure 4-3 shows images from a focus group discussion with data entry personnel at one warehouse, and prototype evaluations at two facilities.

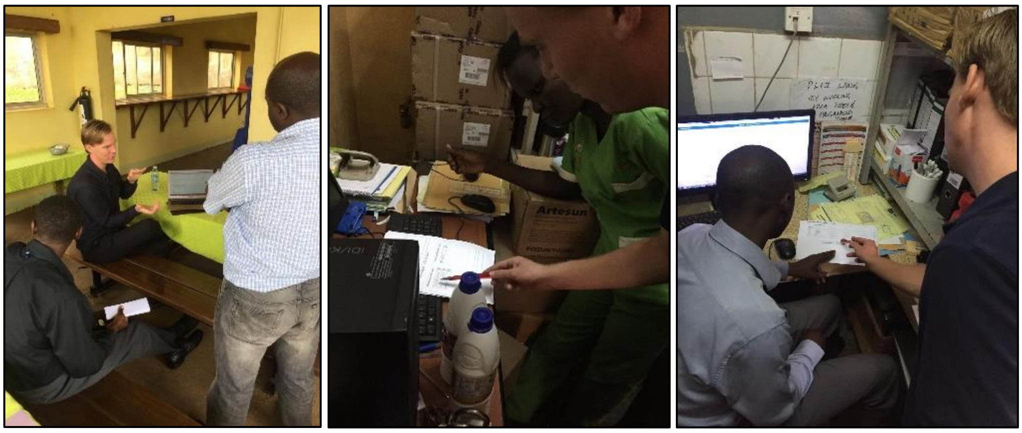


Figure 4-3 Prototype evaluations and discussions

Table 4-5 Techniques for prototyping

Method / Technique	Description
Paper sketches	Paper and pen were used to quickly structure and communicate possible design features for the new interface. Sketches were drawn together with personnel at health facilities and extended and improved based on their feedback.
Digital sketches	Based on the initial sketches, more thorough prototypes were made by digital drawings in Google Draw. This enabled extended prototype fidelity, with a higher level of details on buttons, lists, and colors. The prototypes were printed on paper and discussed with users.
Wireframes	To enable evaluation of interaction, digital wireframes were developed based on the digital paper sketches. With these, users could experiment with the system, by clicking on buttons and lists, exploring possible issues and new opportunities.
Web prototype	Developed with HTML, CSS, and JavaScript, the web prototype enabled high-fidelity prototyping that was flexible to changes based on user feedback.

When the web-based prototype reached a certain fidelity, a video-presentation was developed. The video gave an overview of the key features of the new interface, and enabled communication of concept and form to various actors in Ministry of Health after the second field-trip to Uganda was over. The video was emailed to these actors to stimulate interest and further discussions.

4.4 Methods used in the Evaluation Phase

After the use-oriented design process of the action phase, the prototype was further developed in Norway based on the prototypes designed in cooperation with the participants.

In the evaluation phase, the goal was to evaluate 1) to what extent the changes in the data entry interface implemented in the prototype met the challenges discovered in the diagnostic phase, 2) how this was related to the use-oriented approach to design, and 3) how this was enabled and constrained by the architecture of DHIS2, and its socio-technical environment.

Returning to Uganda in May/June 2017, the final prototype was evaluated with representatives from HISP Uganda, The Ministry of Health, two district health offices, one warehouse and four medium-size public hospitals over a period of two weeks (summarized in Table 4-6). In addition to user evaluation with data entry personnel, discussions were held with relevant actors from the different groups to answer goal 2 and 3.

Table 4-6 User participants in the evaluation phase

Type	Facilities	Participants	District
Medium-size public hospitals	4	8	Kampala, Kayonga, Mukono
District Health Office	2	3	Kayonga, Mukono
Warehouse	1	4	Kampala

Observation and Interviews at Facilities

To evaluate to what degree the prototype met the challenges discovered in the diagnostic phase, four hospitals, one warehouse, and two district health offices were visited. One of the public hospitals and the warehouse had been a part of the preceding design process, three had not. The latter was engaged to get input from new participants, not colored by earlier participation in decisions regarding the design. Further, two of these hospitals did not use the digital solution but submitted order forms on paper. This enabled testing of the interface with users without prior knowledge of the existing digital system.

On each hospital visit, the participants (personnel in charge of submitting commodity orders), were presented with the data entry interface and were asked to fill out the order report form for a specific cycle. Representatives from HISP Uganda, and I, observed and took notes of possible points of confusion, while the participants were asked to think out loud while navigating the system. After this session, the participants were asked some prepared questions. If they had experience with the existing system, questions involved topics on how the prototype was working compared the existing system. With no prior experience, the focus was on the prototypes' relation to the key issues identified in the existing interface during the diagnostic phase.

Before the test and interview, the participants were encouraged to openly criticize the design as domain experts and informed that the research and practitioner team had no interest invested in the result of the evaluation.

At the visits to the warehouse and district health offices, the prototype was presented to the respective data entry personnel in charge of data entry, or biostatisticians in charge of approving incoming order forms from facilities. Discussions were held, posing the same questions as during the hospital visits.

Discussions with HISP Uganda and Ministry of Health

The results from the facility visits were discussed with HISP Uganda and a few representatives from the Ministry of Health. Notes were compared, and findings related to evaluation goal 1 was documented. Further, the different actor's experiences related to evaluation goal 2 and 3 were discussed and written down. Here, the emphasis was on enabling and constraining factors and differences in the two development phases, that is, for the existing interface and the new. Technical components, time, difficulties, the competence that was required, and so forth were main topics. This included mine and other developers' experiences from the design process, and in the later development of the high-fidelity prototype connected to the DHIS2 platform. These are presented as results in Chapter 5.

4.5 Data Analysis

The interpretive nature of this research makes qualitative data analysis an important aspect of the research process. Walsham (2006, p. 320) describes the data that we collect through such studies by Quoting Geertz (1973, p. 9), *"What we call our data are really our own constructions of other people's constructions of what they and their compatriots are up to"*. In this research, these constructions and interpretations has been documented and discussed between the participants to provide a rich picture from each stage of the action research process, in line with Walsham (2006, p. 325) in that *"[...] the researcher's best tool for analysis is his* *or her own mind, supplemented by the minds of others when work and ideas are exposed to them.".* Theory and research literature has played two roles in this research. First, literature on HIS challenges and strengthening, and user participation in design, studied before and during data collection, has affected me as a sensitizing device. Second, the same theory has had a definite role in structuring and guiding the documentation of results, and the discussion provided in Chapter 6.

The approach to data analysis has been twofold:

1) Data has been collected, discussed and documented as results through a hermeneutic process, where mine and other actors' understanding of the phenomenon of focus has been gradually developed through data gathering and continuous discussions with the project practitioners from HISP Uganda and Ministry of Health (MOH), and the end-users included in the diagnostic, action and evaluation phase (data entry personnel and health workers).
2) Based on the documented data, and existing literature, a thematic analysis was used to develop themes and categories, that constitute the answer to the posed research question.

Figure 4-4 provides an illustration of this process.

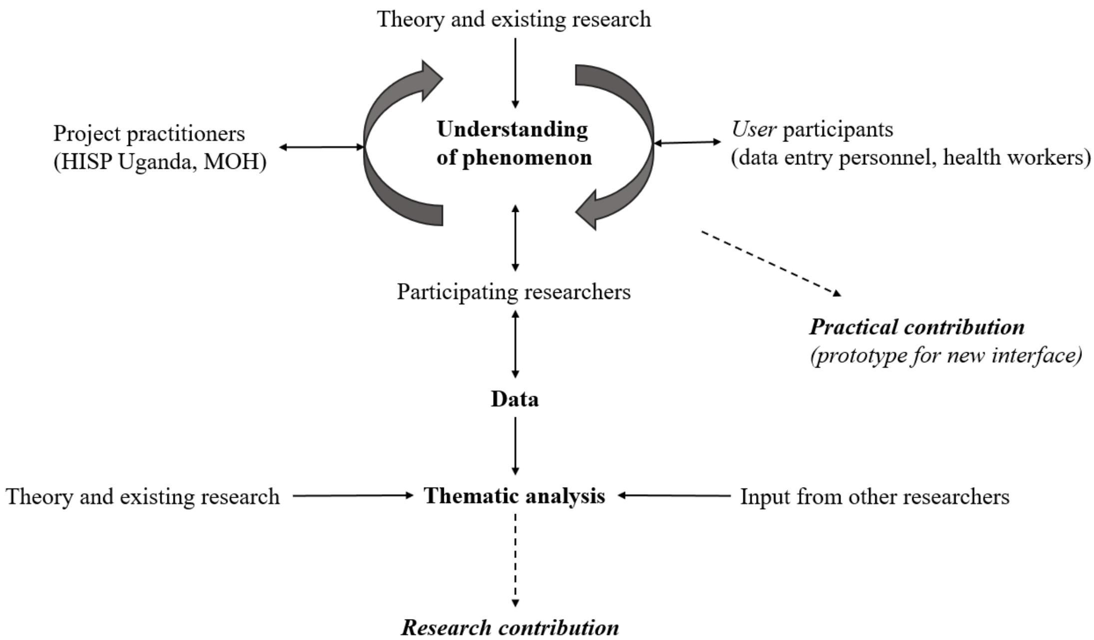


Figure 4-4 The analytical process of this research

4.5.1 Gaining Understanding through a Hermeneutic Circle

As described by Klein and Myers (1999, p. 71), the hermeneutic circle of interpretation is based on the principle that *"we come to understand a complex whole from preconceptions about the meanings of its parts and their interrelationships"*. Understanding a complex phenomenon is based on the understanding of its parts, and how these are related. A strengthened understanding can be achieved through the cyclic process of looking at specific parts of the object of study, which in turn provides new understanding of the whole. *"Our task is to extend in concentric circles the unity of the understood meaning. The harmony of all the details with the whole is the criterion of correct understanding."* (Gadamer, 1976, p. 117).

The principle of the hermeneutic circle provides the basis for analysis in the diagnostic, action and evaluation phase of this research. During the diagnostic phase, the goal was to investigate the existing commodity ordering system. This understanding was built by shifting focus between the specific parts to the overall perspective. Each facility visit focused on the particular work routines, systems and issues of the individual facility, which further built the understanding of the general rules and patterns of the overall system.

After each facility visit summary documents were written jointly between me and representatives from HISP Uganda and, on some occasions, Ministry of Health. Notes from interviews and observations formed the basis for this, in combination with information from the document analysis, and discussions with the practitioners. The summary documents contained a general description of the facility and the location, and details on ordering procedures and systems in use. These were re-read several times during the diagnostic phase to be compared with new visits to other facilities. Figures mapping out the information flow between humans, information systems, and locations were drawn for each facility, district office, and warehouse. These were later compared to identify patterns and deviations. An example of these figures is provided in Figure 4-5.

Based on the challenges identified in the diagnostic phase, the research objectives were updated. Through continuous discussions with HISP Uganda during action planning and the development process in the action phase, knowledge about how the existing interface was designed and what role user participation played in this process was established. During the action and evaluation phase, the objective was to develop a new data entry interface trying to involve health workers and data entry personnel in design. Here, the process of analysis was similar, where each interaction with user-participants and prototyping processes were discussed and documented. Also, notes were taken during participant interaction, prototyping, focus groups and so on, which were compared between the researcher and HISP Uganda afterward to produce summary documents. Learnings related to both the actual interface design and development, and the overall process (related to the theme and research question) was a part of this.

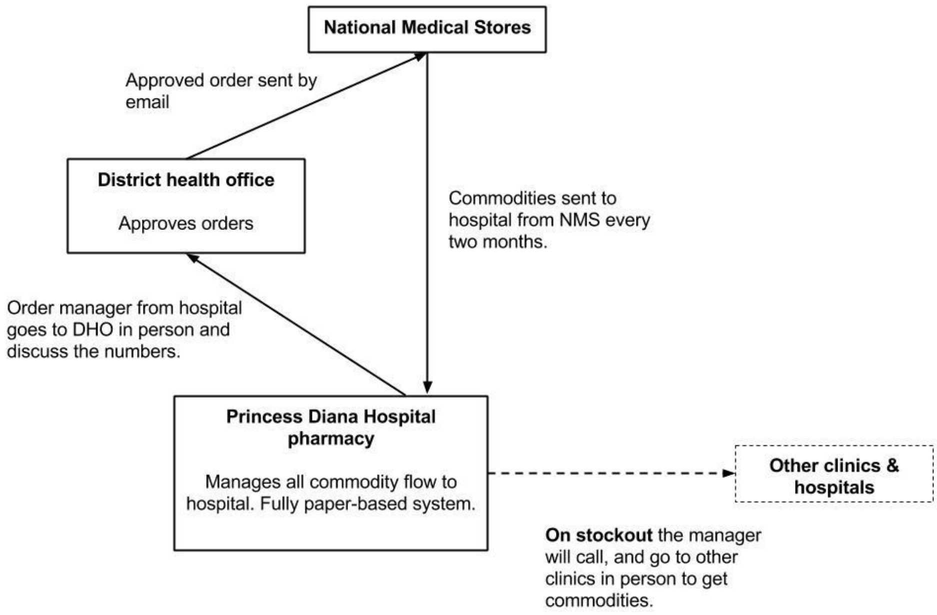


Figure 4-5 Example of figures drawn during facility visits

4.5.2 Thematic analysis

During the hermeneutic analysis process of the diagnostic, action and evaluation phase, knowledge related to the research theme was established. Combined with related research literature, the results that emerged throughout the research phases helped produce the final research question to be answered in this thesis. Objective three of this research was to analyze the processes investigated to identify relevant technical and organizational factors that enabled or constrained user participation. This was performed through a thematic analysis of the documented data.

Thematic analysis is a flexible, yet systematic process for qualitative data analysis, aiming at producing themes emerging from patterns in the data. Braun and Clarke (2006) describe the process of thematic analysis through six stages of 1) familiarizing yourself with the data, 2) generating initial codes, 3) searching for themes, 4) reviewing themes, 5) defining and naming themes, and 6) producing the report. Being based on theoretical concepts, looking for information on specific aspects predefined by the research question that emerged through the hermeneutic research process, the analysis was deductive in nature.

At the first stage, all documented data was reread, before it in stage two was coded by each data element's relation to the research question. In the third stage, which in the words of Braun and Clarke (2006, p. 89) *"re-focuses the analysis at the broader level of themes, rather than codes, involves sorting the different codes into potential themes",* the coded pieces of data were categorized into themes. Some of these themes were derived from existing literature, other created based on the data. Iterations between stage three and four (reviewing themes) were ongoing for some time to ensure that the themes defined reflected the data in a correct manner. A thematic map was created to provide a visual illustration of the themes, and to be able to quickly add, change, remove and organize themes and sub-themes. Finally, in stage five, the resulting themes were named and described and transferred to factors presented in the discussion.

Due to the writing, presentation, and discussion of a conference paper (Li, 2017) (Appendix 2), some of the themes defined in the first round of analysis were discussed with other information systems researchers at the conference. Feedback from this fed into another round of analysis which resulted in modifying existing and adding new themes.

4.6 Summary

To summarize, the methodology of this research has been Action Research. A diagnostic phase uncovered challenges in a commodity ordering system that related to the data entry interface. A research question was defined, and research objectives were updated. The research question and objectives were further updated as the process unfolded. Guided by theory, the challenges identified were addressed in the action phase by developing a prototype for a new interface through a use-oriented participatory approach. The final prototype was qualitatively tested with health workers in the evaluation phase. Understanding has been built and data were documented through a hermeneutic process of analysis. The data has in turn been thematically analyzed to explore the research question. Figure 4-6 attempts to provide a simple illustration of the process, and the practical and theoretical contributions. In the following chapter, the empirical results from the action research are presented.

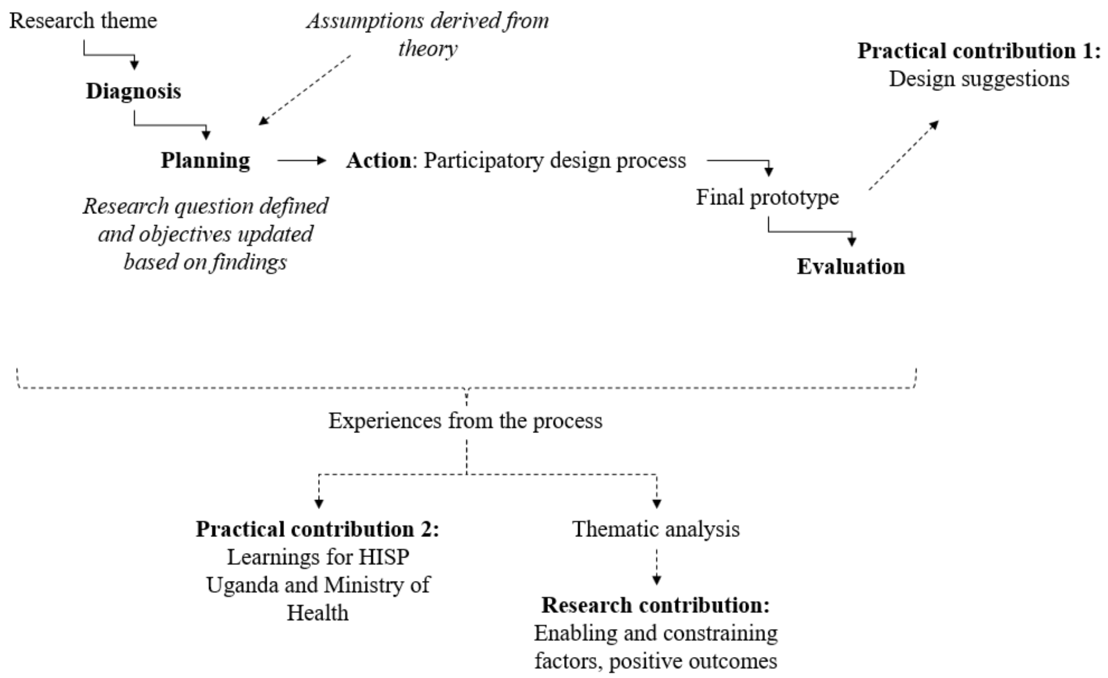


Figure 4-6 Summary of the research process

Chapter 5 - Results

In the introduction, three objectives to answer the research question of this thesis were outlined:

1) Investigate how the existing commodity ordering system and its data entry interface have been designed, and what role user participation played in this process.
2) Develop a new data entry interface trying to involve health workers and data entry personnel in design.
3) Analyze these processes to identify relevant technical and organizational factors that enabled or constrained user participation.

Accordingly, the first part of this chapter will present the results of the investigation of the existing ordering system, how the interface was designed and developed, and issues related to this interface. The second part will focus the second objective - the results from the design and development process of a new data entry interface, where health workers were involved. That is, how the process unfolded and how the design of the final prototype was received by the health workers.

Finally, a summary of the results of most relevance to the research question is provided before the third objective is addressed in Chapter 6, where these results are analyzed to identify and discuss enabling and constraining factors for user participation.

5.1 Part 1: The Existing Commodity Ordering System

This part of the results focus on the first objective of this research and will describe the existing commodity ordering system for ARV-medicines, how the interface was developed and implemented, and issues with this reported by health workers.

The organizational structure of health commodity ordering in Uganda has in later years been streamlined and standardized. In one of several disease-specific ordering regimes, a web-based commodity ordering and reporting system (referred to as WAOS) has been implemented. Before details of the development and implementation process of WAOS are presented, the following section will outline the fundamental components and overall structure of commodity ordering in Uganda.

5.1.1 The Overall Structure of Commodity Ordering

Health facilities in Uganda, such as health clinics and hospitals are categorized into 7 groups based on size and level of expertise (Table 5-1).

Table 5-1 Groups of hospitals and health clinics in Uganda

Level	Type
7	National Referral Hospitals
6	Regional Referral Hospitals
5	District Hospitals
4	Health Centers
3	Small health clinics with in-patient ward
2	Small health clinics without in-patient ward
1	Outreach-teams

Outreach teams are subordinate to a health clinic on level 2 or 3. Hospitals and clinics on level 5 – 2 are supervised by the local District Health Office, which functions as a mediator of order and consumption reports between the facility and the warehouse. The national and regional Referral Hospitals are more autonomous and report directly to the warehouse and Ministry of health. Figure 5-1 provides an overview.

Hospitals and clinics order and receive commodities from national suppliers. There are three leading medical suppliers involved in the public health commodity supply chain in Uganda. National Medical Stores (NMS) is publicly owned, and the largest medical supplier in the country. Second largest is Joint Medical Stores (JMS), which was started as a joint venture between Uganda Catholic Medical Bureau and Uganda Protestant Medical Bureau. Also, Medical Access Uganda Ltd. (MAUL) accounts for a small share of the supplies to the public sector. Each medical supplier has one or several warehouses in the different regions of Uganda.

Common for the three is that they receive their medicines from a) organizations that specializes in trade of health commodities, and b) international donor organizations.

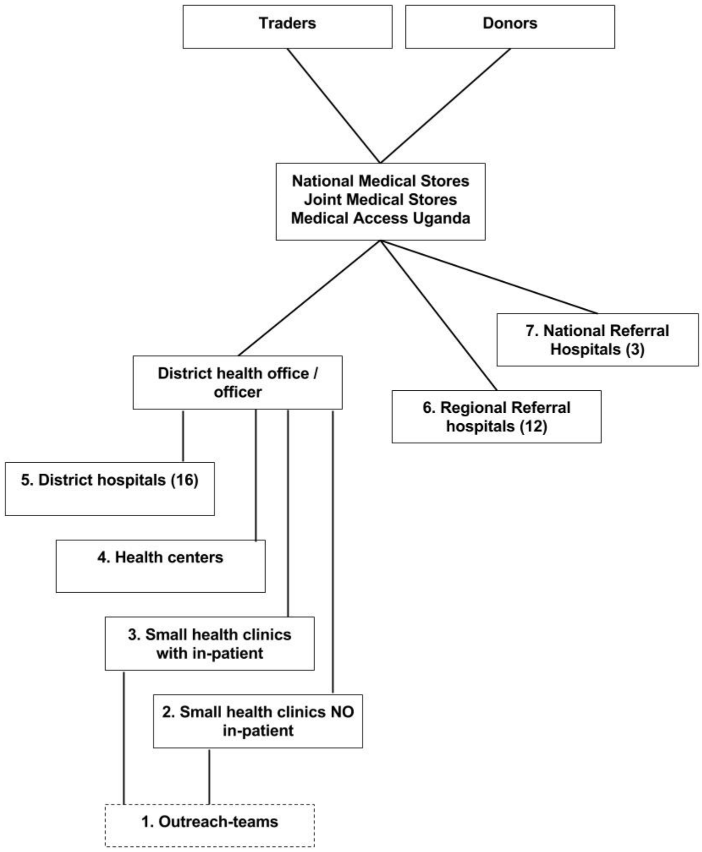


Figure 5-1 Overview of the health facility structure in Uganda

The overall health system is separated into disease-specific programs, such as the National Tuberculosis and Leprosy Program and the HIV control program, which are funded and directed by the Ministry of Health, in cooperation with various donor agencies as 'implementing partners'. Six of these programs has their own reporting regimes with standardized forms for orders and consumption reports. There is no standardized automatic exchange of information between these programs. However, at the clinic and district level, comparisons of data are performed by humans manually. On the national level, joint-program planning and information exchange occurs through meetings and workshops.

Shipments and orders are performed in bimonthly cycles, defined by the commodity supplier assigned to a specific health facility. This means that facilities are attached to a specific warehouse of one particular provider, such as NMS. All program-specific forms for that facility will be sent to this warehouse.

The Order Forms

While the forms in the system are referred to as orders, they collect data on several aspects, such as consumption, stock levels, and stock-outs. The quantity to be shipped for next cycle is calculated based on the numbers for the previous cycle. Forms are submitted from the health facilities each cycle, and the commodities are delivered before a certain date next cycle.

All of the program-specific ordering forms follow a common structure. For each commodity, the health facility reports several numbers related to consumption, stock on hand and days out of stock. For example, the order and consumption report form for the ARV and E-MTCT program contains the elements outlined in Table 5-2.

Table 5-2 Data elements for each commodity in the ARV form

Data element	Description
Opening balance	The count of stock on hand at the start of a cycle.
Quantity Received	What quantity was received at the previous delivery.
ART & PMTCT Consumption	The total consumption of this commodity during the cycle.
Losses and adjustments	The number of medicines lost received or exchanged with other facilities during the cycle
Days out of stock	The number of days with no commodity in storage during the cycle
Adjusted AMC	An adjusted average monthly consumption. A number calculated based on the consumption this cycle, and the days out of stock
Closing balance	The count of stock on hand at the end of the cycle
Months of stock on hand	How many months of stock which is available in storage at the facility. Calculated using the closing balance, and adjusted AMC
Quantity required	The actual number ordered for the next delivery. This is also calculated using the adjusted average monthly consumption, and months of stock on hand.

Considering the 36 commodities to order, this adds up to 324 data elements to be filled in on the ARV form. Further, several of the data elements are calculated based on other data elements in the form, such as the ‘adjusted average monthly consumption’. The actual number to order for next shipment is the ‘quantity required’, which also is calculated based on other data elements.

All the forms in the different programs have grouped their commodities into sections. For the ARV form, it is separated into ‘Adult Formulations’, ‘Pediatric Formulations’, ‘E-MTCT only formulations', 'Third-line formulations', and 'Other formulations'. Each of the section contains four to ten formulations, which refers to one or a combination of up to three medicines.

Patient summaries

In addition to statistics on specific commodities, the form contains a large section with patient summaries. Here, statistics on the number of new and existing patients are reported, based on age and medicine formulation. For the ARV form, this makes up 206 data elements to be reported each cycle. These numbers are amongst other purposes used to triangulate data reported on the commodities.

Order Flow

Order forms in the different programs go through the same three stages before the commodities are shipped.

1. Data entry
2. Approval
3. Dispensing

Pending on the level of the health facility, these three stages take place in two or three locations. If the health facility is classified as a level 6 or 7 hospital, the approval is performed by the head of the pharmacy directly at the hospital. If it is classified as level 6 or lower, it will be approved by the district health office. The form is then forwarded to the relevant warehouse for dispensing. Figure 5-2 illustrates how the order form flows from facility to warehouse.

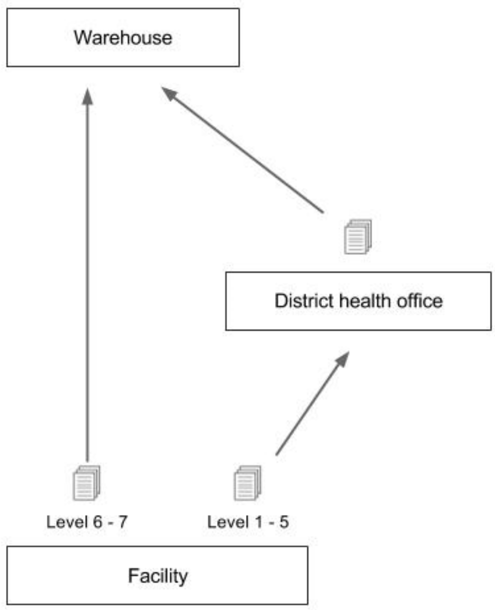


Figure 5-2 Flow of order and consumption report forms in the supply chain

The information is treated and used differently in these three locations, and each will be described in the following sections.

Health Clinics and Hospitals

At the health facility, the personnel in charge of logistics (in smaller facilities, these are often health workers such as nurses) fill out the order and consumption form for all relevant programs. Information relevant to the entry process is gathered from dispensing logs, tally sheets and physical counts in the local storage. Some facilities have a computer with the forms in Excel format. They fill out the form in Excel and send it as an email to the district office, or warehouse. Those that do not have a computer, which includes most facilities, use pen or pencil to fill out the form on paper. A calculator is used to calculate the values for the combined data elements. Some facilities have implemented the computer-based system ‘RX-Solution’ to manage stock-levels and register dispensing and the arrival of commodities. This system can also be used to send order forms by email to the district health office or warehouse. These forms are Excel versions of the paper forms, which has to be filled out and attached to the email. However, due to the unstable power supply, these facilities keep a complete paper-based system in parallel. Figure 5-3 shows pictures from the office in a medium-size hospital where forms for inventory and ordering were kept. A variety of forms and guideline-documents are used to support the management of commodities. On the second picture from the left, the health worker wears a t-shirt with instructions to send an SMS to a specific phone number when stock-outs occur. This system, and whoever had provided the facility with these t-shirts was, however, unknown to the health worker.

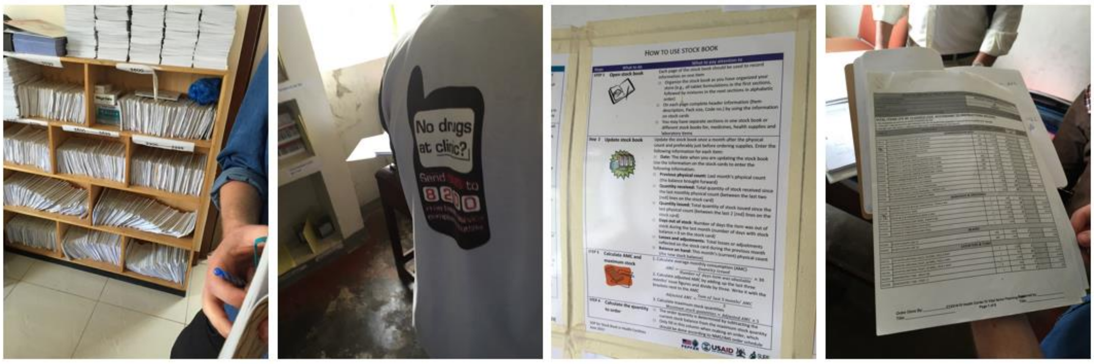


Figure 5-3 Various documents and forms at a hospital

Due to a limited number of pharmacy professionals a proportion of the data entry personnel at clinics and hospitals are doing this as an additional task, combined with other duties, such as routine reporting or patient care. This depends on the size and level of the health facility. If the facility is classified at level 6 or 7, the ordering form is brought to the head pharmacist at the hospital after data entry, which looks it over and approves it. Figure 5-4 provides a simplified illustration of the systems in use by a health facility worker in charge of commodity ordering.

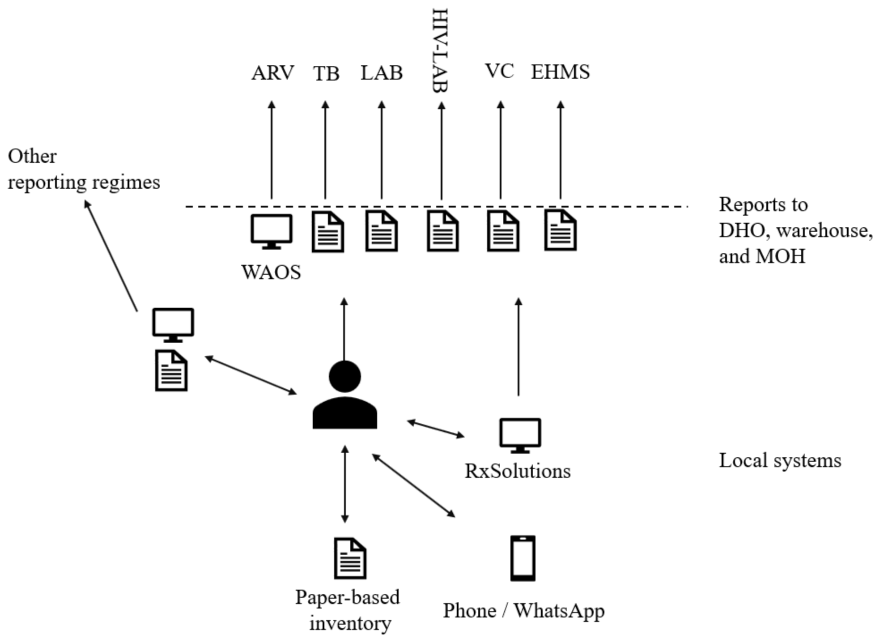


Figure 5-4 A simplified illustration of the systems in use at clinics and hospitals

District health offices

When a form is received from a facility, the biostatistician or other qualified personnel goes through the numbers on the form. If any abnormal values are discovered, he or she contacts the facility to follow up. Some health centers are bringing the hard copy to the district office in person. Here, they sit down with the biostatistician to go over the values together. This is described as both a thorough way to verify the numbers on the form and a learning mechanism to further develop the skills of the representative from the health center.

Warehouses

When an order form is received at the relevant warehouse of a medical provider, the value representing the quantity to order for each formulation is entered into their own digital system. The system takes care of inventory and ordering from external suppliers, such as trading and donations. At Joint Medical Stores, they use the enterprise resource planning software IFS (Industrial and Finance system). A generic software package developed by an international company based in Sweden. The quantity ordered for each formulation is entered into IFS, which automatically generate and update picking-lists for shipments, inventory, and later, external orders to their suppliers. Figure 5-5 illustrates the internal flow of order information at JMS. The data entry into DHIS2 is further described in the next sub-chapter.

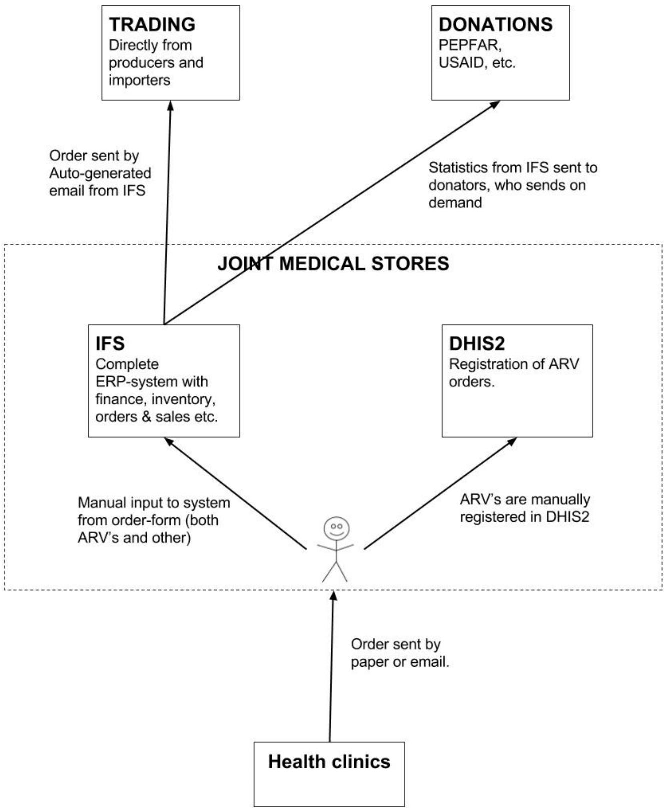


Figure 5-5 Internal flow of order information at Joint Medical Stores

With this overview of health commodity ordering in general, the digital solution developed and implemented in the ARV-program will now be described in detail.

5.1.2 Computer-based Ordering and Reporting with WAOS

As part of a more extensive strengthening process of the health commodity supply chain, in 2009 the Management Sciences for Health (MSH), funded by the United States Agency for International Development (USAID), initiated the 'Securing Ugandans' Right to Essential Medicines' program (SURE). In cooperation with the Ministry of Health Resource Center and the Aids Control Program, a part of this strengthening initiative was the development of WAOS for ordering HIV-related antiretroviral medicines (ARV) (SURE, 2014). Utilizing contemporary technological solutions, the primary objective of the WAOS project was to simplify ordering and promote data quality, timeliness, completeness, and access to data for decision makers. The centralized digital ordering system was developed to support ordering and reporting of ARV-related health commodities throughout the health system. It was developed and implemented by the local HISP node, HISP Uganda, as a part of the existing national health management information system (HMIS) software platform, powered by the generic software package DHIS2. Details of the development and implementation process will be outlined in the following sections.

HISP Uganda as Developers and Implementers

The local Kampala-based organization HISP Uganda was contracted to implement the technical part of WAOS on the national DHIS2 instance. The organization had earlier overseen other implementation initiatives directed the Ministry of Health and was also involved in maintenance and development of the existing national DHIS2 instance.

HISP Uganda is a part of the global HISP project and possess extensive competence in DHIS2 development and implementation. As described in Chapter 2, the global HISP project emphasizes local competence building in the involved countries to promote local sustainability without dependency on the foreign developers situated in Europe. Further, the core developers and HISP collect generic requirements for further development of DHIS2 through use cases and experiences reported from the local nodes such as HISP Uganda. Lead representatives from these nodes are invited to workshops both in Europe, the US, Africa and Asia to discuss and share requirements that both shape the further development of DHIS2 and builds and sustains local competence. HISP Uganda is highly active in this network.

A central arena for local competence building is the DHIS2 academies, established to teach both new and experiences implementers on both technical and organizational factors relevant for customization, development, and implementation of DHIS2 and HIS in general. The academies are arranged in a variety of countries every year, with topics ranging from basic setup and configuration, information use, server administration, and configuration for specific domains and use cases (DHIS2.org, n.d.-b). Several of the HISP Uganda staff have participated in one or several DHIS2 Academies, which have made them highly competent in implementation and development and connected them to other HISP nodes and the global community.

As HISP Uganda was in close contact with the core developers of DHIS2 and the HISP community, the global lead developer of DHIS2 also was engaged in the development and implementation. Working together with the local team, the developer assisted in both discussions regarding how to set up the data structure, and in actual implementation.

Use of DHIS2 in WAOS

As briefly described in Chapter 2, DHIS2 is used as a national data warehouse in Uganda, storing data and providing functionality for a variety of health programs spanning several domains. In this case, a single instance of DHIS2 is running on a central server and is accessible to health facilities, Ministry of Health and other actors through a web-portal. A section of the

Ministry of Health is responsible for maintenance and further development of the national DHIS2 instance. WAOS was implemented by HISP Uganda as an independent health program on this national instance. It was therefore of importance to set up the system without too much interference with the established health programs, as this would require coordination with these.

Configuration

As requirements vary between the implementing countries and domains, DHIS2 is designed as a platform. The platform core provides standard, but flexible functionality to support storage of data elements, and so-called indicators that are combinations of data elements, which together provide useful information or *indications* on the status of a particular phenomenon, such as mortality rate or HIV medicine coverage. Also, the software core includes functionality for setting up organizational hierarchies based on the structure of the implementing organization. Further, a layer of *bundled apps* (apps that are included as a standard part of the software package) provides functionality for data collection, analysis, and presentation of indicators. This layered structure enables new health programs to set up their reporting regimes within an existing instance without affecting existing implementations.

The basic requirements of WAOS were implemented using these standard configuration tools provided by the DHIS2. Data elements were configured to store the values of the items collected through the form. Other built-in functionalities in DHIS2 were then used to design reports and visualizations to be used in operational and strategic decisions by district health offices, warehouses, the Ministry of Health, and implementing partners. Since the software instance was already used by other health programs in Uganda, an organizational structure with districts, hospitals, and other facilities was pre-configured. For DHIS2 to support the more particular requirements for the WAOS project, some configurations were needed. For example, DHIS2 has a specific way of storing *when* a form or incident have occurred. To align this with the logic of bimonthly order cycles present in the existing health commodity ordering system, a script was created to map months to the cycles of different start and end-dates.

Customizing the Data Entry Interface

The tool for data collection in DHIS2 is developed to support a variety of devices such as desktop computers, smartphones, and tablets. Moreover, these are customizable through several built-in design tools, each providing possibilities for customization of the data entry interface used by health workers (DHIS2.org, n.d.-a). The following options are available:

1. Standard forms: the form is autogenerated based on the data elements selected for the collection.

2. Section forms: the designer can split up the form into sections and select which data elements that are to be shown in each section.
3. Custom forms: the designer is free to use web programming languages such as HTML, CSS, and JavaScript to create a custom layout.

The two first options require no programming experience and are therefore relatively easy to use without developer competence. As the third option involves web programming, some additional competence is needed pending on how advanced layouts and functionality that are to be implemented. Further, all options can be used without interfering with existing health programs on the shared software instance.

The data entry interface for WAOS was designed to be used on desktop computers and based on the layout of the existing paper-based ARV order and report form. The built-in 'custom form' tool in DHIS2 was used to implement the design by a software developer in the HISP Uganda team. The tool, combined with some custom-made scripts enabled the interface to automatically calculate values in the form that was based on the sum of other values. Further, the layout was tested by one logistics expert and program manager at the Ministry of Health. Small configurations in the custom forms tool enabled the developer to quickly respond to the feedback from the manager and present the changes for further discussion. By using custom forms, evaluating with one manager, and mostly basing the design on the existing paper form layout, the process was quick and only required a couple of days of work.

Organizational setup

After the system was developed, workshops aiming at training district personnel in the new system were arranged. When trained, the participants further shared their knowledge with other relevant health personnel in their district. Desktop computers were installed at the enrolled facilities, and internet access was ensured by using mobile network adapters. The left picture in Figure 5-6 shows WAOS in use at one warehouse, where several of the personnel use the interface to retrieve data to generate orders or enter data into the system from paper forms on behalf of facilities that lack computers. The middle picture shows a health clinic worker taking us through the process of filling out the order form on their desktop computer.

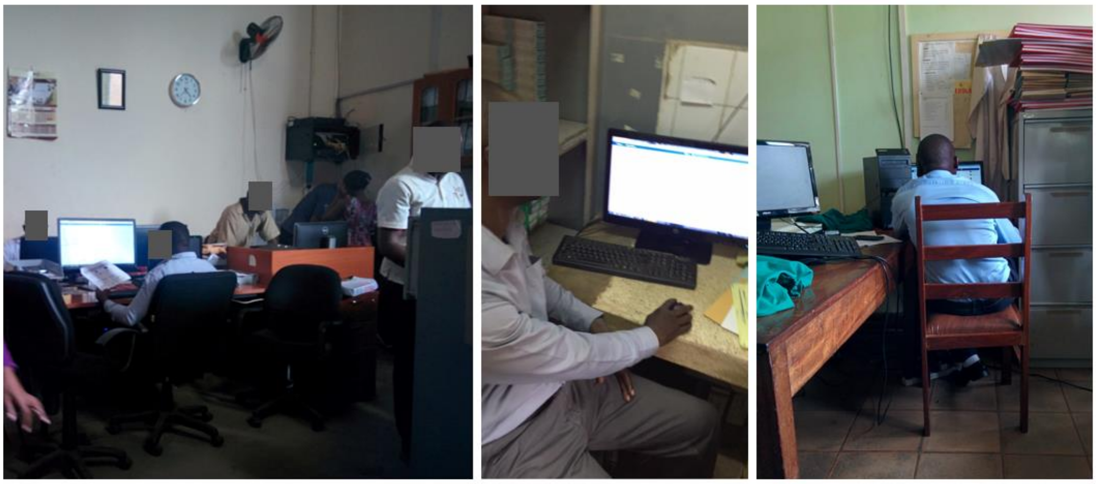


Figure 5-6 WAOS in use at warehouse and two health clinics

Since most health facilities in Uganda still lack computers and stable internet connection, a structure of paper-to-computer gateways were designed. Health facilities without a computer send their paper report to their district health office. If they have computers, they will enter it into DHIS2 after approval. If not, they will forward the approved paper order to the correct warehouse, where it will be entered into DHIS2 as shown in Figure 5-6. Figure 5-7 illustrates the flow of order forms in the partly digital regime.

If a report is entered digitally at the health facility, it will immediately be available for inspection and modification at both the district health office, and the warehouse. Due to limitations in the component used in DHIS2, and in resources for training, no formal system for approval was implemented in the digital solution.

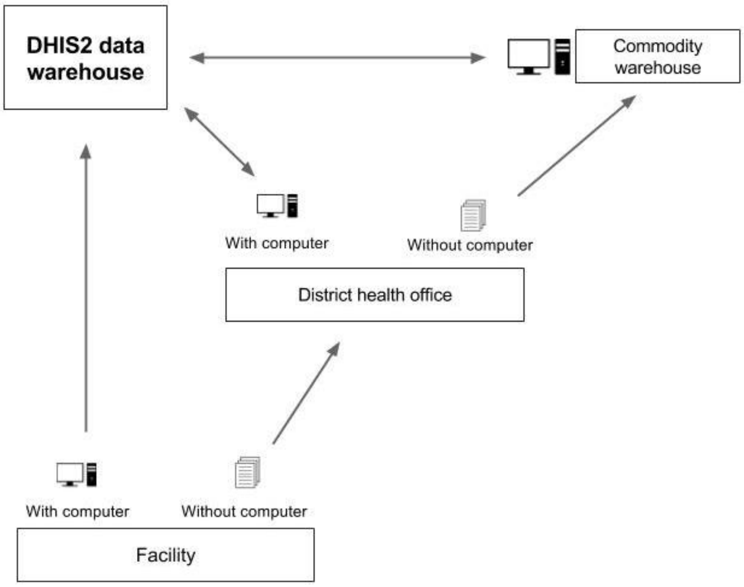


Figure 5-7 Flow of orders in the ARV program using DHIS2

WAOS was introduced in April 2013 and is now widely used throughout the country (SURE, 2014). Further adoption by new facilities is mainly constrained by access to the internet or stable electricity, and resources for training of personnel to use the system. Figure 5-8 show the share of health facilities at various levels that have internet access, and where personnel have been trained for WAOS as of 2014 when the SURE program ended.

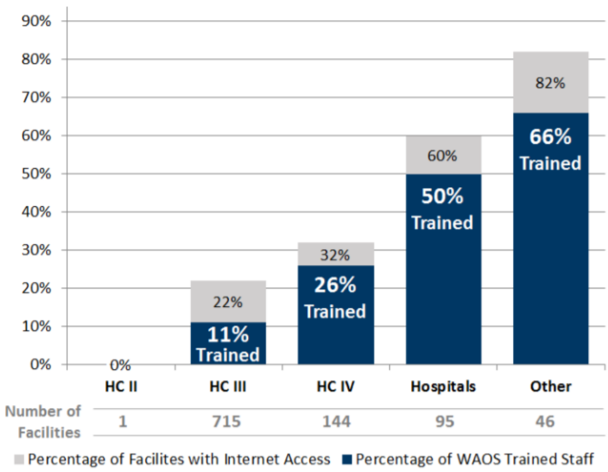


Figure 5-8 Staff trained to use WAOS, and access to the internet in 2014 (from SURE, 2014).

5.1.3 Experiences After the Implementation

The transition from the old paper system to DHIS2 has been described as quite successful, especially regarding the availability of information in use for decisions for top management and planning. In a project summary report by the SURE project, they conclude that the WAOS project has been successful in improving data quality, reporting rates and completeness. They also emphasize how the system has decreased the work-load related to compilation of data from paper orders at the central level. With the order and report data stored in the DHIS2 data warehouse, information is now instantly available to all relevant actors. The report concludes that *"The system has proven to be a substantial advantage over the original paper-based system"* and further *"Since WAOS was introduced in April 2013, reporting rates have generally improved, especially for public health facilities that order from NMS"* (SURE, 2014, p. 30).

In 2016 a process was initiated to expand the WAOS solution to include commodity ordering for the Tuberculosis and Leprosy program.

Challenges with the Data Entry Screen

During the diagnostic phase of the action research project of this thesis, several representatives from Ministry of Health expressed the same positive experience as outlined in the SURE project report. However, challenges were also discovered. A primary concern was the data entry interface of the collection tool in DHIS2 used by health workers to enter commodity orders. Health workers consistently reported that the digital interface introduced issues that increased the burden on the health personnel, and that data quality suffered due to entry errors. Specifically, the interface provided problems on three aspects;

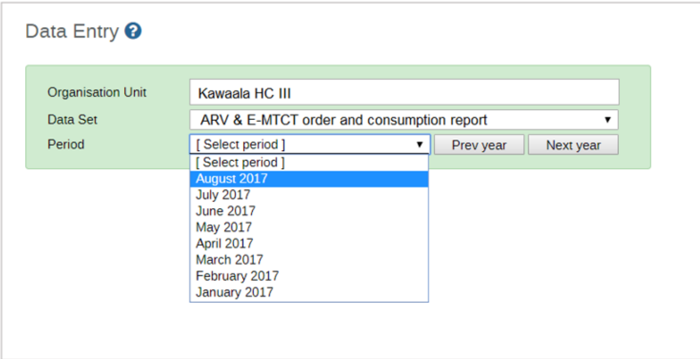
1) Finding and selecting the form for the right reporting cycle.

2) Lack of a visible indicator of which forms that was completed.

3) Entering data into the large form using keyboard and mouse.

Issue 1: Selecting forms by cycle

The screen for selecting forms based on facility and time-period are originally designed to support fixed months. The organizing of forms by cycles with different start and end dates did not match the logic of dates in the interface, which created confusion. The logic of bi-monthly cycles was strongly established in existing work routines and other supporting artifacts such as paper forms and guideline documents. In the computer-based interface, users had to choose between fixed months when selecting a form. To solve this misfit, the users were instructed to select the last month in the cycle they wanted to display, as a workaround. During visits to health clinics, personnel were observed to choose the wrong period on several occasions. Figure 5-9 shows the screen for choosing cycles to the left, and how cycles are presented in the established delivery schedule form (right).



CYCLE	ORDER DEADLINE	DELIVERY ENDS
CYCLE 1	16-Jun-16	02-Aug-16
CYCLE 2	16-Aug-16	23-Sep-16
CYCLE 3	07-Oct-16	16-Nov-16
CYCLE 4	30-Nov-16	03-Feb-17
CYCLE 5	17-Feb-17	30-Mar-17
CYCLE 6	13-Apr-17	26-May-17

Figure 5-9 Mismatch of entry interface (left) and the cycle logic (right)

Issue 2: Indicators of form completion

The various paper systems at clinics and hospital pharmacies often relied on the visibility of physical paper forms as a reminder of finished and unfinished tasks. Participants reported that the digital interface lacked this immediately visible indicator of form completion and now required additional work to identify submitted forms. When moving towards the inclusion of forms from other programs, such as the Tuberculosis and Leprosy program, the users were concerned that this issue will be even more prominent.

Issue 3: Data Entry on a Computer Screen

Due to the digital layout being designed to look like the paper form, entering data into the digital form itself was described as overwhelming by many of the entry clerks, making the entry process a hard and unpleasant task. The number of input fields presented on the screen required scrolling in both horizontal and vertical direction, a complicated task for users with limited experience with desktop computers. The entry personnel described the process of data entry as one which requires time, and deep concentration to avoid entry errors.

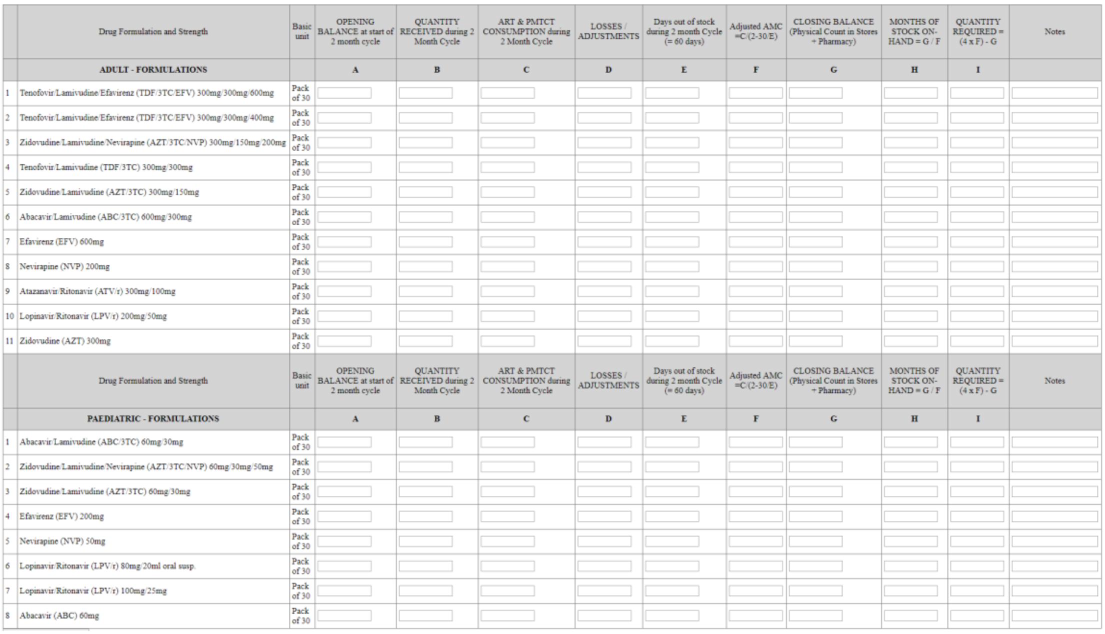
"The form is tricky. It's easy to enter data in the wrong column."

- Health worker at a level 3 health clinic

"You see, the fatigue associated with working on a screen overloaded with information is huge."

- Data entry clerk at district health office

One frequently occurring problem was that values were entered in the wrong column. When discovered by the entry clerk, the use of a computer mouse is required to go back and change the value, while simultaneously looking at the original paper form. Often, these errors are not discovered. This was confirmed by the workers at district and warehouse level, reporting that they too often see strange or misplaced values in the digital form. If discovered, this requires the extensive task of contacting the facility by phone to get the correct data. If it's not recognized, errors in data might result in fatal consequences, such as dispensing of inaccurate amounts of commodities. This was also confirmed by representatives from the Ministry of Health, the District Health Office in Kampala and one of the warehouses visited. They explained that a significant amount of work was related to correcting strange values in the received forms. Much of these were suspected to be due to data entered in the wrong column. A screenshot of a small part of the interface for data entry is provided in Figure 5-10.



	Drug Formulation and Strength	Basic unit	OPENING BALANCE at start of 2 month cycle	QUANTITY RECEIVED during 2 Month Cycle	ART & PMTCT CONSUMPTION during 2 Month Cycle	LOSSES / ADJUSTMENTS	Days out of stock during 2 month Cycle (= 60 days)	Adjusted AMC =C/(2-30/E)	CLOSING BALANCE (Physical Count in Stores + Pharmacy)	MONTHS OF STOCK ON-HAND = G / F	QUANTITY REQUIRED = (4 x F) - G	Notes
	ADULT - FORMULATIONS		**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	
1	Tenofovir/Lamivudine/Efavirenz (TDF/3TC/EFV) 300mg/300mg/600mg	Pack of 30										
2	Tenofovir/Lamivudine/Efavirenz (TDF/3TC/EFV) 300mg/300mg/400mg	Pack of 30										
3	Zidovudine/Lamivudine/Nevirapine (AZT/3TC/NVP) 300mg/150mg/200mg	Pack of 30										
4	Tenofovir/Lamivudine (TDF/3TC) 300mg/300mg	Pack of 30										
5	Zidovudine/Lamivudine (AZT/3TC) 300mg/150mg	Pack of 30										
6	Abacavir/Lamivudine (ABC/3TC) 600mg/300mg	Pack of 30										
7	Efavirenz (EFV) 600mg	Pack of 30										
8	Nevirapine (NVP) 200mg	Pack of 30										
9	Atazanavir/Ritonavir (ATV/r) 300mg/100mg	Pack of 30										
10	Lopinavir/Ritonavir (LPV/r) 200mg/50mg	Pack of 30										
11	Zidovudine (AZT) 300mg	Pack of 30										
	Drug Formulation and Strength	Basic unit	OPENING BALANCE at start of 2 month cycle	QUANTITY RECEIVED during 2 Month Cycle	ART & PMTCT CONSUMPTION during 2 Month Cycle	LOSSES / ADJUSTMENTS	Days out of stock during 2 month Cycle (= 60 days)	Adjusted AMC =C/(2-30/E)	CLOSING BALANCE (Physical Count in Stores + Pharmacy)	MONTHS OF STOCK ON-HAND = G / F	QUANTITY REQUIRED = (4 x F) - G	Notes
	PAEDIATRIC - FORMULATIONS		**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	
1	Abacavir/Lamivudine (ABC/3TC) 60mg/30mg	Pack of 30										
2	Zidovudine/Lamivudine/Nevirapine (AZT/3TC/NVP) 60mg/30mg/50mg	Pack of 30										
3	Zidovudine/Lamivudine (AZT/3TC) 60mg/30mg	Pack of 30										
4	Efavirenz (EFV) 200mg	Pack of 30										
5	Nevirapine (NVP) 50mg	Pack of 30										
6	Lopinavir/Ritonavir (LPV/r) 80mg/20ml oral susp.	Pack of 30										
7	Lopinavir/Ritonavir (LPV/r) 100mg/25mg	Pack of 30										
8	Abacavir (ABC) 60mg	Pack of 30										

Figure 5-10 A small part of the digital data entry screen.

These issues formed the basis for the action phase, where a new data entry form was designed. Results are presented in the following part of this chapter.

5.2 Part 2: Developing a New Data Entry Interface

Based on the challenges presented in the previous section, a new data entry interface was developed by me in cooperation HISP Uganda, Ministry of Health and health workers at clinics, hospitals, district offices, and warehouses. This part of the results focusses on the second objective of this research, and present results from the design and development of a new data entry interface prototype. However, the scope is not to present detailed results on possible layouts and suggestions for future design (the final layout is presented in detail in Appendix 1), but rather to present the experiences from the process itself, to enable an informed analysis and discussion of the enabling and constraining factors of the process in line with the posed research question.

5.2.1 Planning - Generic versus Specific

In the action planning, all actors agreed that a redesign of the data entry interface would be relevant to strengthening the ordering system. However, there were different views on how this should be done. A debate on whether to focus on generic requirements or the particularities of the existing routines of ordering in Uganda emerged.

HISP Uganda is as described in Chapter 2, a part of a larger network through the HISP project. Further development of DHIS2 is ensured by making generic components based on use-cases in specific countries so that they can be useful in other implementations. Following this philosophy, HISP Uganda wanted the interface to be designed as a generic solution that could serve any commodity ordering procedure, *"similar to a web shop ordering system such as you find at Amazon.com"* (Developer at HISP Uganda). An order of X number of commodity Y should be placed, and the system should support the process of approval and dispatch. One of the main arguments for this approach was that if time and resources were to be invested in the development of a new interface, the solution should be useful beyond the Ugandan use-case.

During discussions on this generic model with representatives from the ARV-program at the Ministry of Health, it was quickly emphasized that, even though this might be a nice addition to the DHIS2 suite of applications, it would not serve their needs in the case of health commodity ordering and consumption reporting. This due to the particularities of commodity orders as they were implemented in both the current paper and computer-based system WAOS. This triggered a debate on whether to make something generic where the organization adapted to more general requirements, or aim to specifically support the local practice in Uganda, where the system is adapted to the organization. Based on the challenges identified and knowledge established in prior research on HIS strengthening, I argued for the organization-specific approach, aiming at supporting the established work practices. The main argument was that the relatively generic existing interface implemented in WAOS had introduced such issues, that more domain and context-specific design were needed. These arguments aligned well with the Ministry of Health's wish for a specific solution, and HISP Uganda agreed to support this approach as I would have time to facilitate development.

How to Learn About the Established Practices

After it was agreed that the interface should be designed to suit the established practices, the question was how to gain knowledge of this. HISP Uganda had limited experiences with graphic design and user-oriented approaches as the team mostly consisted of technical programmers and HIS implementers. One alternative would be to put more emphasis on design and domain-expert evaluation than in the first design phase. However, based on existing research on user involvement in information systems design and experiences from prior projects, I suggested following a Participatory Design inspired approach. In the suggested approach, the problems described by health workers during diagnosis would be addressed by engaging end-users at clinics, hospitals, district offices, and warehouses in the design process through several iterations of prototyping, and user engagements. Both HISP Uganda and Ministry of Health saw this as a sound and feasible approach as long as I would take a leading role in the process, having prior experience with such methods. The other actors agreed to help with development and implementation, and facilitate visits to hospitals, clinics, district offices, and warehouses.

Implementation in DHIS2

To support requirements gathered through user participation, HISP Uganda and I discussed how to best implement this in DHIS2. It was argued to be beneficial to use one of the built-in tools of DHIS2 as they were easy to use and enabled a fast implementation. As described, the first interface was implemented in DHIS2 using the built-in 'custom forms' tool to customize the standard data entry application. While the custom form tool provides the most design flexibility of the available options, this is limited to customization of the actual form. Issues discovered during diagnosis revealed that some of the issues in the existing interface were beyond the design of the form itself. This related to issue 1: 'selecting correct form by cycle', and issue 2: 'lack of immediate feedback on the completion status of forms'. Further, issue 3: 'too much information on the screen during data entry' was not easy to solve with the custom form tool. An alternative would be to use the built-in *section form* tool, to easily split up the form into several sections, but this would limit the flexibility to respond to the ideas and feedback of the participants.

However, in addition to the standard bundled apps for data entry, DHIS2 supports the development of *third-party apps,* in its outer platform layer. This is enabled by an Application Programming Interface (API) following the widely used web standard REST. With this, implementing organizations can engage developers to produce custom applications that respond to needs and requirements not supported by the core functionality or the bundled apps. These applications utilize the API to communicate with the resources of the core and can be included in the platform and easily accessed by users through the web portal. It was therefore decided to utilize this outer layer of the DHIS2 platform and develop a custom *third-party web app*. This was argued to provide the needed flexibility to address the outlined issues and other feedback from end-users, both regarding experimenting with the layout of the form itself, and with the screen for period/cycle selection and to display form status for recent and upcoming cycles. As this option would require more advanced programming skills and knowledge of how the DHIS2 API and related resources work, I used some time to familiarize myself with the DHIS2 online documentation. I also attended one of the DHIS2 academies in Rwanda where form design and some API usage was one of the topics. Table 5-3 gives a summary of the available options for data entry interface customization in DHIS2. 'Custom forms' were used in the existing interface of WAOS, while the custom app was used in the new due to increased flexibility. This however required additional skills.

Table 5-3 Data entry interface customization options in DHIS2

Tool/option	Design limitations	Skills required
Standard form	Only predesigned form layout.	Basic computer usage
Section form	Only predesigned form layout split into defined sections.	Basic computer usage
Custom form (used to design the first interface)	Only customization of the form itself. No drastic changes to structure and process.	Basic HTML, CSS, and, JavaScript if needed.
Custom app	No limitations.	Advanced HTML, CSS, JavaScript, Ajax and DHIS2 API.

Furthermore, as the data structure, reports, and visualizations for commodity orders already had been set up in DHIS2, it was important that the development of a new interface did not intervene with these existing components. Due to the layered nature of DHIS2, the web-app could be connected to the already existing data structure set up in DHIS2. Also, in parallel with the redesign of the data entry interface, another project was ongoing, where a researcher together with the HISP Uganda team explored alternative configurations to the underlying data structure. It was argued that by building the interface in a web-app provided the opportunity to rapidly reconfigure it to work with a new data structure at a later stage if needed. Figure 5-11 gives an illustration of how the new data entry interface as a module could be developed and connected to the existing data structure, without disrupting established components. If the current data structure were to be updated, the custom app could quickly be updated to work with this.

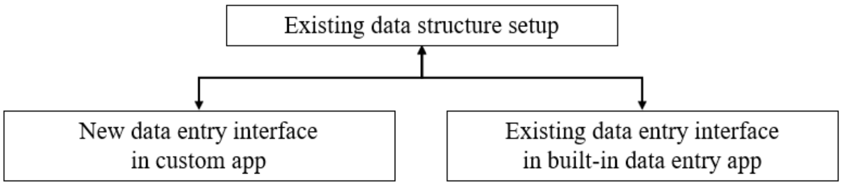


Figure 5-11 Modularity: Data entry interface as a module

Related to this modularity, another benefit from building a custom app, was that development could be done without any coordination with other health programs using the same national DHIS2 instance. This was argued to be of benefit compared to customizing the interface by changing the core code of DHIS2 based on the open source license, as this would require extensive coordination with national maintenance and other health programs. Also, doing changes in the existing code would be significantly more difficult and time-consuming.

5.2.2 The Design Process

When the agreement had been reached on making an interface based on established routines through user participation by building a *custom app*, the iterative design-process described in Chapter 4 was initiated. While the methods and techniques used in the process are described in that chapter, the following sections provide experiences from the execution of this process.

Arranging User Interactions

Due to infrastructural conditions and cultural aspects of time, language, and formalities in Uganda, it was difficult to execute a structured plan, and the process unfolded quite pragmatically. Planned group sessions and meetings were canceled at last minute, while new opportunities emerged without warning. For example, while visiting a district health office outside of Kampala, a larger focus group was planned one week in advance on that same location. Preparations were done, and expectations were high as this seemed like an excellent opportunity to involve several frequent users in an early phase of prototyping. When the day came, we called our contact person to confirm that they were ready to receive us in a couple of hours. However, we were now told that all employees were at a seminar in another district and further that they would not be available in the coming weeks. No explanation of the sudden change of events was ever provided, and we had to look for other opportunities. Hence, evaluations and focus groups were held when the opportunity presented itself. I was at times quite frustrated with some of these difficulties, while the team from HISP Uganda explained that such experiences were quite typical when working within the public health sector. Over time, I adjusted to these circumstances and learned to be more pragmatic.

Although a preferred method within the tradition of Participatory Design, it turned out that it was difficult to gather several participants in one workshop. Health facility pharmacies are usually understaffed, leaving limited time for additional tasks. To adapt to these circumstances, the team traveled between different facilities, engaging users one-by-one or in smaller groups at their location. Hours were spent in traffic jams on our way to health facilities, so discussions between the included actors and preparations for the next visit were often done in the car. This put extended pressure on me as a mediator, as I had to mediate suggestions made by users at one facility, to other users at other locations. Even though it was emphasized to make the users in charge of all decisions, this distributed process implied that the HISP team and I had to make some tradeoffs regarding what to forward to preceding user interactions. The evolving prototypes were a central enabler of communication across different locations. Figure 5-12 attempts to illustrate how I had to mediate between actors and users on different locations.

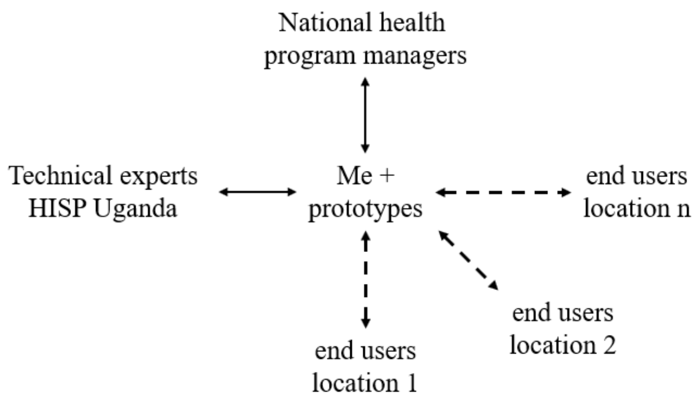


Figure 5-12 Me as a mediator between actors and locations

Moreover, gaining access was not a trivial process. For instance, when visiting a hospital outside of Kampala, one of the hospital managers denied us access as she had not been informed of our visit in advance. Typically, a call from the right person at the ministry needed to be placed to local authorities to arrange such meetings. As seen, these were later canceled without warning or justifications. Letters from directors in Ministry of Health was provided to ensure cooperation from hospital and warehouse authorities, which was delivered to the relevant person in charge at each visit during a formal meet and greet taking a few minutes up to an hour. Eventually, the team was introduced to appropriate personnel at the facility, and the actual session of discussing issues, prototyping or evaluation performed. In Figure 5-13 we see focus groups at two warehouses, where it was possible to gather several users of WAOS at the same time. The time spent in traffic were used to discuss and document previous user interactions and plan for the next.

Figure 5-13 Focus groups and working in traffic

Enabling Actual Participation

When formalities had been taken care of, the participants at all sites visited proved to be eager to participate and showed great enthusiasm. At times, it was challenging to promote critical feedback on the prototypes presented. For example, the following experience was noted during a visit to a facility with the first paper-based prototype:

"First, they were fascinated to see their ideas materialized in a more detailed sketch. Due to the fidelity of the prototype, it was a bit challenging to facilitate constructive criticism on the design proposals."

A quote from one of the participants was also noted. *"This is very good, especially if I can send in all reports here [...] when will this be ready to use?".* This illustrates the level of satisfaction expressed by the participants at such an early stage of the design process. However, after some positive feedback, the participants usually started to identify issues and possible improvements. For example, when presenting an early sketch of the new interface, one of the participants thought that it looked too different from the table on the paper form. Other layouts were discussed, and ideas for improvements were materialized in prototype with the user, and later designed in higher fidelity, before presented again. Figure 5-14 provide pictures from prototype discussions at two clinics, and while waiting for introductions to a third. While waiting (righthand picture) ideas and challenges posed by users at previous visits were discussed within the team. On the middle picture, the participants compare the prototype with existing paper documents, to discuss how the design can best suit existing practice.

Figure 5-14 Prototype discussions

At some occasions, the presence of representatives from Ministry of Health seemed to affect the participants in that they were a bit more careful when expressing their opinions. In these situations, the participants looked at the Ministry personnel while talking, possibly modifying their criticism. In visits where these representatives were not present, this phenomenon did not occur.

Overall, by dealing with the challenges described, both mine and the HISP teams experience was that health workers could be engaged and participate in all aspects of the design process, from defining problems, generating ideas, and decisions regarding major and minor decisions.

Prototyping

As it was decided to develop a custom app, there was no pre-existing interface provided by DHIS2 to configure to rapidly present suggestions for design. Therefore, and as described in the research approach, several prototyping techniques were used during the design process. First, basic paper sketches were produced in initial discussions with participants, before these were developed into digital wireframes, and finally as a web-based prototype with HTML, CSS, and JavaScript. It was experienced that as the fidelity and granularity of details in the prototype increased, the type of feedback changed. In the paper-based prototypes, participants expressed criticism of fundamental aspects of concept and structure. In the later versions, participants showed more interest in detail such as placement of buttons and input fields, colors and text labels. Figure 5-15 shows the evolution of one of the screens in the prototype, from paper to wireframes, to web.

During the process, several user participants expressed concerns regarding unstable internet connection and power supply. The ones that used WAOS also kept a full paper-based system in parallel to avoid losing data if blackouts occurred. By using contemporary HTML5 solutions in the custom application, offline browser technology was used to rapidly support usage during internet blackouts. The same technology allowed us to make the application continuously save the current data entry stage locally, to resume at the same stage automatically if the computer was restarted. These user requirements were relatively easy to prototype, test, and evaluate with users due to the flexibility provided by developing a custom app, which enabled utilization of established components of the HTML5 standard.

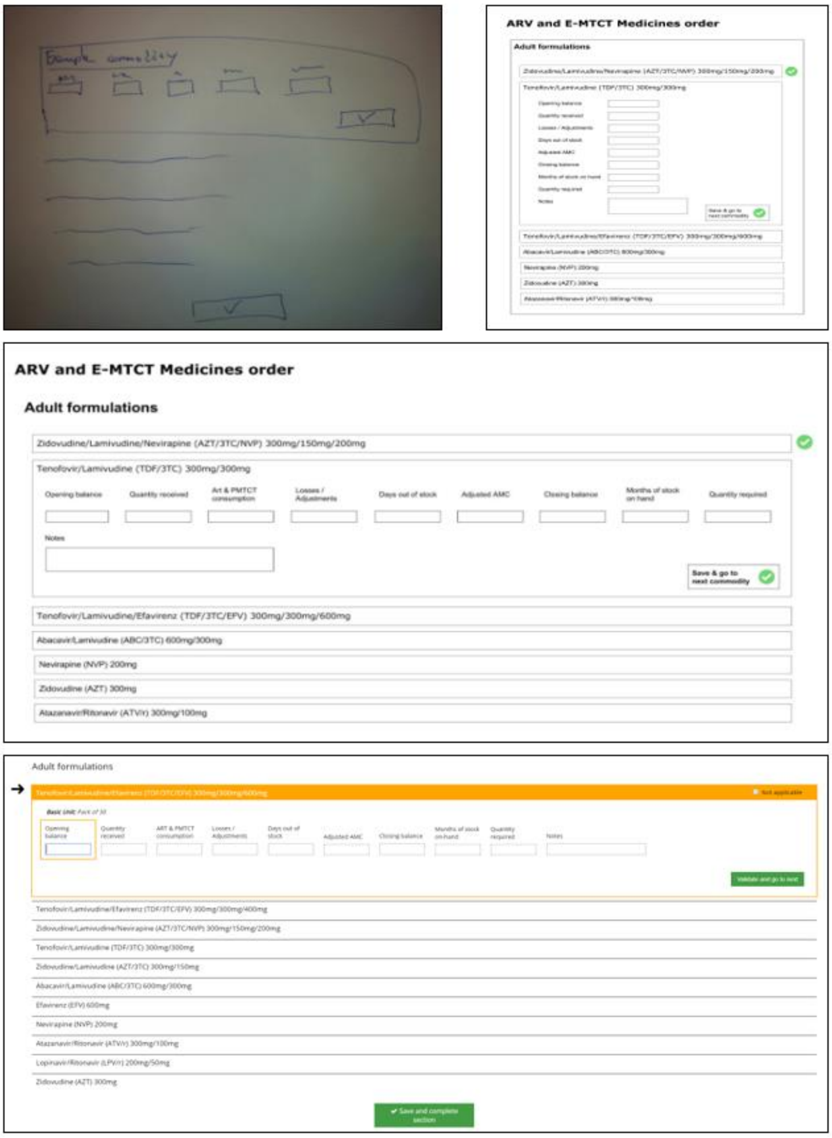


Figure 5-15 Evolution of the data entry interface prototype

The Final Prototype

As described in Chapter 4, the design process lasted for five weeks. Table 5-4 provides a summary of how the three key issues in the existing layout were addressed in the resulting prototype. Further, Figure 5-16 provides a comparison of the layout for selecting forms by cycle and data entry in the old and new interface. For a detailed description and illustrations of the final design, see Appendix 1.

Table 5-4 How key issues in the old interface are addressed

#	Key issue in the old interface	The solution in the new interface
1	Selecting correct form by cycle.	A dashboard that displays the relevant forms for the current cycle. Old forms marked with cycle name.
2	Lack of immediate feedback on the completion status of forms.	Dashboard with lists by status, and status indicators on the forms in the list.
3	Too much information on the screen during data entry. Misplaced values.	Data entry 'wizard', dividing the entry process into steps based on form sections and individual formulations and commodities. In-line data entry validation with error messages.

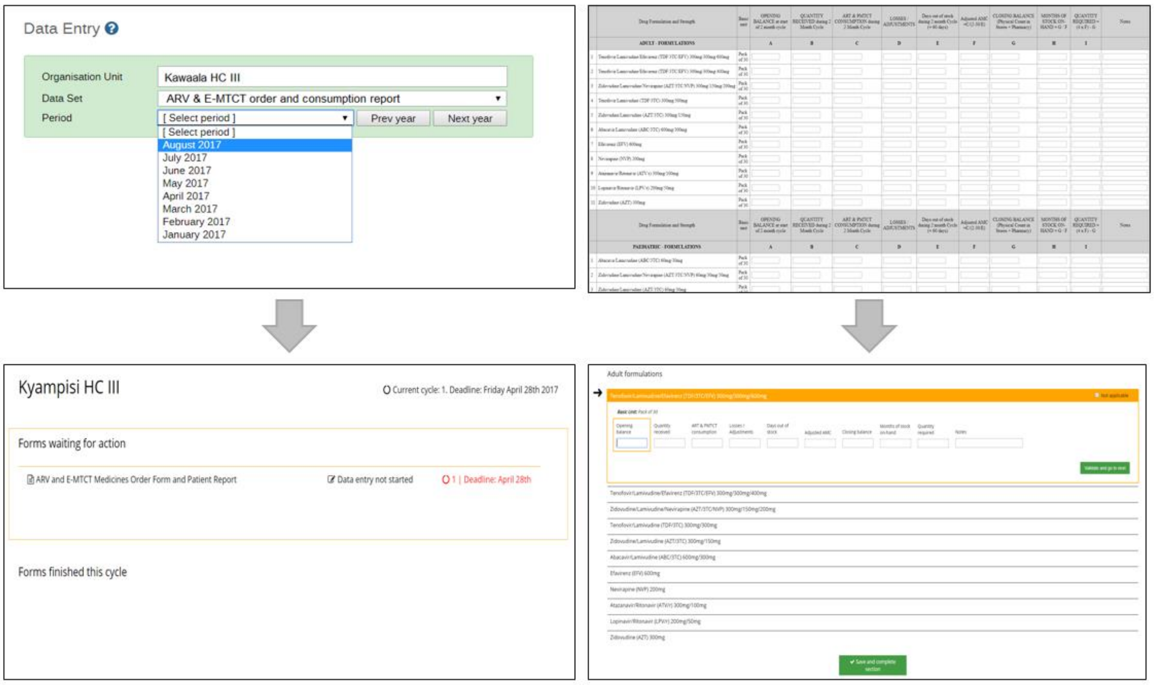


Figure 5-16 Comparison of the layouts of old and new interface

After the design process, I returned to Norway and further developed the prototype into an actual web-app which was connected to the DHIS2 data structure. This process took about four weeks. HISP Uganda and Ministry of Health wanted the interface to be tested with a real functioning data structure, before combining it with the established system on the national DHIS2 instance. The prototype for a proposed new data structure, developed by the other researcher in cooperation with the HISP team provided an opportunity for this, and the interface app was configured to communicate with the data structure prototype. This system was evaluated by health workers in the evaluation phase, and the results are presented in the preceding section.

5.2.3 Final Evaluation

As mentioned, three key issues with the existing data entry interface of WAOS were described and defined by the health workers in the diagnostic phase:

1) finding and selecting the form for the right reporting cycle.

2) lack of a visible indicator of which forms that was completed.

3) entering data into the large form using keyboard and mouse.

As a part of the evaluation phase of the research project, final prototype evaluations with both experienced users of the existing data entry interface, and users of the paper-based forms were conducted. The goal was to evaluate whether the new interface addressed these three challenges, through qualitative feedback from participants that both had and had not been involved in the earlier design iterations. Discussions aimed at getting the participants own interpretations of the interface, and whether it solved critical issues in the existing one.

When presented with the dashboard, and asked to complete simple tasks, participants were observed to quickly familiarize with the layout. They expressed satisfaction with how forms were presented as submitted or pending for action and that cycles were automatically presented on the screen, with no need of selecting illogical time periods as in the old interface. The possibility to have forms for ordering other types of commodities were posed by several participants. One commented:

"This is very good, especially if I can send in all reports here."

Further, participants at both warehouse, district, and clinic/hospital level expressed a positive attitude towards the stepwise data entry process, that only presents input fields for one commodity at the time. This was also the experience when observing the participants while completing tasks such as filling out the form in the new interface. After some initial instructions, all participants were able to complete the entry process without help from the facilitators. When testing the stepwise data entry screen one participant working as a data entry clerk a warehouse commented:

"Isolating one and one commodity I think will make the work easier for the guys here also."

The data entry clerk and the colleagues he refers to use the existing interface daily, as they function as a paper-to-computer gateway that enters data from paper forms on behalf of clinics and hospitals. Another frequent user of WAOS at a district health office was also positive towards the new way of entering data:

"This is good since it filters out all other information making it easy to see what we are typing for."

Referring to the aim of improving clarity to avoid entry errors, her comment "To see what we are typing for" indicates that the design might address some of the issues experienced. Moreover, in addition to avoiding entry errors, several participants argued that the design would make data entry a more pleasant task. This was elegantly articulated by a health worker at one of the clinics visited:

"It's good with less information because the people that enter see that there is some progress. More motivating".

This positive attitude related to how it could improve their work day was further emphasized by another clerk at the warehouse visited:

"Thank you so much for working on this system, I think it will improve our work day a lot."
Data entry clerk at a health clinic

As the using WAOS and its existing data entry interface was a significant part of their work day the warehouse workers were eager to start using the new interface. After testing the complete process, from the dashboard to data entry, one participant commented:

"When will this be implemented so we can use it? I ask because you are now getting us all excited and we want the system now."

One of the managers from Ministry of Health that had been present during several user interactions in both the action and evaluation phase commented that this seemed to be a major improvement to the existing system. He was fascinated to see the level of satisfaction and engagement expressed by the health workers. When asked what he thought of the prototype and design process, he further articulated that *"You know, this is one of the greatest things that have happened within our program"*.

Table 5-5 Summary of results in the final evaluation

Issue	The solution in the new interface	Result
Selecting correct form by cycle.	Dashboard	Health workers quickly familiarized with the layout, selecting the right cycle and form. Comments made by the participants were in line with this.
Completion status of forms.	Lists by status and status indicators on the forms	Health workers were observed to find completed and uncompleted forms without assistance.
Too much information on the screen during data entry. Misplaced values.	Data entry 'wizard.'	Participants could finish the process after a brief introduction. All expressed positive attitudes related to improved user satisfaction and reduced entry errors.

5.2.4 Engaging Actors from other Programs

During presentations of the prototype to the Ministry of Health, representatives from other health programs, such as the Central Public Health Laboratories (CPHL) expressed interest in implementing WAOS. As the same health workers are responsible for reporting to all health programs, the usability and end-user acceptance of the solution, indicated by involved data entry personnel, was an attractive feature of the solution. This triggered a process, where the development team was invited to a CPHL seminar. Here, the prototype and the design process that it was based on was presented to key actors. One participant articulated the enthusiasm for the prototype by joking about calling the United States Agency for International Development (USAID) immediately to get donor funding for implementation:

"Call USAID, we need funding for this now!"

Later an additional meeting with CPHL were arranged, where possible implementation of the system for HIV-test kit order and consumption form were discussed with a whole team of technical personnel. In addition to the attractive traits of the DHIS2 system, all agreed that the prototype's foundation in requirements originating from participation with data entry personnel in design made the solution attractive.

An agreement was reached, that HISP Uganda and a representative from CPHL would stay in touch and that they would plan for implementing the DHIS2 with the data entry interface presented after it was implemented in the ARV-program.

5.2.5 Further Development

The data entry interface is now being developed further by a team of two new master students. One will concentrate on the user interface and further user engagement, evaluations and prototyping, while the other will work on implementing it with the existing underlying system in DHIS2. However, around the time that the final prototype was evaluated, a representative at the Ministry of Health with close relations to HISP Uganda left the Ministry to work elsewhere. As this person had been a critical driver and mediator in the process, this introduced challenges in maintaining the project for further implementation. Communication with other representatives have been established, but it has been proven difficult to build the same kind of enthusiasm around the project again. Time will show whether this will be achieved, allowing the implementation process to continue.

5.3 Summary

The results presented in this chapter have covered a variety of aspects related to the two first objectives of the research of this thesis.

A summary is here provided before we turn to analysis and discussion.

Part 1: Health Commodity Ordering in Uganda and WAOS

Health commodity ordering for public health facilities in Uganda is divided into six disease-specific programs. Each has their own order and consumption report form that are sent from a health facility, approved by the district health office, or the head of the pharmacy at the facility before forwarded to the warehouse for dispensing. The forms include a high number of data input fields to report on consumption, stock-outs, stock balance and the number of commodities required in the next cycle for each commodity. For the ARV form, this adds up to 324 data elements. Also, the forms often include reports on patient statistics used for triangulation (206 elements for ARV).

The ARV-program have implemented a computer-based ordering system using the existing national health management information portal based on the DHIS2 software (WAOS). The local HISP node, HISP Uganda was in charge of the development and implementation process. For many facilities, data is now reported using a digital data entry interface on a desktop computer. However, due to limited computer and internet coverage at health facilities, both computer and paper-based ordering are used in parallel throughout the country. To address this, paper to computer -gateways have been established at district and warehouse level that receive papers from lower levels, and enter the data into the digital system. The WAOS is viewed as a successful initiative to digitize ordering and consumption reporting of ARV medicines. Data is instantly available to relevant actors through the DHIS2 platform, and data quality and reporting rates have improved. Its success has motivated the Tuberculosis and Leprosy program to plan for implementation of the same solution.

The data entry interface of WAOS was designed using the bundled app *custom form* in DHIS2, which enabled quick customization to make the digital interface resemble the existing paper layout. However, it was consistently reported that the digital interface introduced issues that affected data quality and user satisfaction. These issues were related to the size of the form and how forms and cycles were displayed in the interface, which differed from established practice.

Part 2: New Data Entry Interface

To address the challenges of the data entry interface, a design process was initiated. After discussions on whether to design a generic or specific interface, an agreement was reached on engaging end-users from all levels in producing a prototype for a new interface more suited for the data entry personnel, their work practices, and environmental conditions. I, as an involved researcher had a central role in these negotiations, promoting user involvement as a way of ensuring a fit between technology and use. To avoid the constraints introduced by the built-in tools for customization and have extended technical flexibility to respond to user suggestions and feedback to solve the issues found, it was decided to develop a *custom app* for DHIS2. Here, the interface could be designed in any way, and later be connected to the existing data structure through the API. Participatory design techniques such as prototyping, focus groups, and evaluations were a central part of the process. Although there were several challenges related to the execution of the process such as logistics, access, and enabling criticism, the experience was that engaging end-users were fruitful in building a mutual understanding of established routines and technology. Based on this understanding, the resulting prototype attempts to address issues with a form dashboard screen, and a stepwise data entry process. Final evaluations indicate that the end-users prefer the new design and that it addresses the critical issues discovered in the existing interface. Moreover, during meetings with the Ministry of Health, other health programs expressed interest in adopting the same solution. An attractive trait was the prototype for a new interface and the process on which it was designed.

The two Design Processes

Interface design and development unfolded under different circumstances during the two design processes outlined in part one and two. Most noticeable, the level of user involvement and evaluation was higher in the second process. Further, the aim was different in that the second process mostly concerned data entry interface design and the other focused on a variety of elements. Different technical components were used to implement the interface, based on issues found and on my promotion of participatory approaches. Also, competence on the latter was present during the second design process, while the first process mostly included technical expertise. The extended focus on user participation and choice of technical solutions that were more time-consuming regarding development resulted in a significantly longer duration of the second process. For comparison, Table 5-6 summarizes the development processes of the two interfaces presented in these results.

Table 5-6 Summary of the two interface design processes

	The first interface	**The second interface**
Aim	Development of interface as one part of a larger project	Improving interface that was experienced to introduce issues.
Competence in the implementation team	Software development, HIS strengthening	Software development, HIS strengthening, participatory approaches to design.
User participation	One program manager	Several health workers from all levels that use the existing systems (both paper and computer)
Competence on user involvement required	Basic context-appropriate social skills, prototyping using built-in tools in DHIS2.	Context-appropriate social skills, methods for participation such as contextual observation, interviews, focus groups, prototyping such as paper-sketches and wireframes.
Underlying technical system	The shared national DHIS2 software instance	
Technical component used	'Custom form' tool in DHIS2	Custom app using the DHIS2 API
Technical competence required	Basic HTML, CSS and JavaScript.	Advanced HTML, CSS, JavaScript and experience with the DHIS2 API.
Duration	About two days	Four weeks of user engagement + about four weeks of development

Based on the results presented, several factors can be identified as influencing the level of user involvement in the design process of the two interfaces, and the ability to customize the software and engage users in this. Also, we can see that there might be some positive outcomes from a more 'use-oriented' focus during design and development. In the following chapter, we turn to objective three of this research, to analyze and discuss these results in the light of related literature and the research question.

Chapter 6 - Analysis and Discussion

This chapter will address the third objective of this research; to analyze the two processes investigated to identify relevant technical and organizational factors that enabled or constrained user participation. Hence, the presented results will be analyzed and discussed in the light of literature presented in Chapter 3. First, some of the challenges related to HIS will be briefly discussed. In Section 6.2, enabling and constraining factors for user participation in the empirical case is examined to answer the research question of this thesis:

Which factors might enable or constrain user involvement when designing data entry interfaces in a generic health information software?

Further, both literature and the empirical case of this research indicate that the user interface can be related to several aspects of HIS strengthening. Indications of such positive outcomes identified will be discussed in Section 6.3. In Section 6.4, reflections related to the approach and process of the research conducted will be provided, including limitations and implications.

6.1 Challenges with WAOS

The results from the diagnostic phase reveal that the information system that supports health commodity ordering of ARV medicines in Uganda constitutes a variety of established work routines, computer and paper-based components, and organizational and political actors, profoundly affected by its socio-economic context. As seen in Chapter 3, existing HIS literature (e.g., Braa & Sahay, 2012a; Lippeveld et al., 2000) suggests that there are some shared challenges in developing countries, that are related to this complex environment. Results from the diagnostic phase of this research project indicate that these issues are relevant in the health commodity supply chain in Uganda. This section will briefly discuss some of the difficulties found.

Electricity and Internet Access

Due to lack of a stable supply of electricity and internet access, the ability to install computer-based information systems at a large array of facilities are limited, especially in rural areas. A common way to deal with varying computer access is to establish paper to computer gateways at the lowest level where computers can be installed (Braa et al., 2007). This same principle has been followed in WAOS, where facilities without computers send their reports by paper to the district health office for data entry into the DHIS2. Moreover, fiber-optic landlines are only available in the larger urban areas, and health clinics and hospital are seldom connected to these. However, mobile internet coverage through 3G and 4G technology have been discussed in the literature as a strong enabler of computer-assisted reporting at lower levels (Sæbø et al., 2011). This technology has been rapidly expanded in Uganda the latest years (see Chapter 2), and now seems to be dominant in providing internet access to health facilities. This development has been a fundamental enabler of the WAOS project.

Fragmentation

A large body of literature such as Lippeveld et al. (2000), Braa and Sahay (2012a), Windisch et al. (2011), suggests that fragmentation due to parallel reporting regimes is a significant challenge in countries where the health sector is primarily funded by donor agencies. In the commodity supply chain of Uganda, we can see that six programs are each managing independent reporting regimes. Although there exist arenas for communication across these programs through discussion meetings in the Ministry of Health, and at district health offices, any standardized and automatic flow of data between them is lacking. Moreover, there is no exchange of data with other health reporting regimes, such as those that manage routine health data. Combining information from these sources is argued to be of substantial value for strategic decision-making (SIAPS, 2014), as it can provide program managers and other actors with valuable indicators to manage resources efficiently. This makes integration a major common goal in HIS strengthening (Sæbø et al., 2011), and of great relevance to Uganda.

Fragmentation was also found in the local information management regimes at the health clinic and hospital level. The limited coordination between disease- and domain-specific programs seemed to increase workload associated with data reporting, as multiple forms with different layouts had to be managed by health-workers with severe time constraints. To support the process, a patchwork of local paper-based systems, smartphone applications, and computer systems was used without being fully standardized or integrated into the WAOS system. Based on this, it seems that facility workers have found workarounds to compensate for lacking functionality and flexibility in the WAOS solution and the systems for other programs. Existing literature describes this as a common phenomenon when such technical systems design fail to meet established work routines and contextual conditions (Gasser, 1986).

Data quality and Timeliness

Emphasized by scholars such as Lippeveld et al. (2000) and Braa and Sahay (2012a), HIS in developing countries suffers from limited data quality. They argue that this can be a result of several factors, such as limited technical skills and training of data entry personnel, lack of equipment, inappropriate data collection tool design, and low motivation for data reporting at the point of data entry. When SURE initiated the WAOS project in Uganda, data quality and timeliness was reported as low (SURE, 2014). At the end of the project when WAOS had been implemented, statistical indicators reported significant improvement. However, during the diagnostic phase of this research, several actors reported that the digital data entry interface was associated with challenges affecting both data quality and timeliness. The issues seemed to occur due to misfits between the digital design, and existing routines. Forms for the correct cycle was hard to find, and the layout of the paper form was not appropriate for a desktop computer screen due to its size. As a result, wrong cycles were selected, and data were entered into the wrong column, affecting data quality. In line with Lippeveld et al. (2000), data quality suffered as the form was not designed with the health workers in mind, failing at providing a layout with sufficient clarity.

User Dissatisfaction

AbouZahr and Boerma (2005) and Lippeveld et al. (2000) describe how the health workers' main concern is clinical care and that data reporting is perceived as an additional task. Thus, the motivation for dedicating time to fill out forms might be limited. Further, it is argued that unclarities in the layout of such forms might limit this motivation as it makes the process challenging. For the WAOS system, participating health workers consistently reported that the data entry interface made the reporting and ordering process an unpleasant task. In the words of a data entry clerk at a district hospital *"You see, the fatigue associated with working on a screen overloaded with information is huge."* Again, these issues seemed related to a design that was insensitive to the users and their local routines. In section 6.3 the issue of user dissatisfaction will be discussed further in relation to interface design.

The concern expressed by the data entry clerk illustrates how end-users are affected by the technology that is being implemented. By engaging these users *before* implementation and during the actual design, developers might avoid producing systems and interfaces that negatively affect work satisfaction and data quality (Kensing & Blomberg, 1998; Kyng, 1994; Lippeveld et al., 2000). However, as both existing literature and the empirical findings of this thesis indicate, this is not straightforward when working with a generic software package (Bansler & Havn, 1994; Fischer, 2008) developed globally (Roland et al., 2017), and implemented in a developing country context (Puri et al., 2004). The following section will discuss the enabling and constraining factors of engaging health workers such as our entry clerk during design in the Ugandan project.

6.2 Enabling and Constraining Factors for User Participation

To strengthen data quality and timeliness, Lippeveld et al. (2000) argue that tools for data collection in HIS should be designed based on the knowledge of relevant health facility workers through user evaluation. Further, an extensive body of literature suggests that user participation in the design of information systems enable *"'artful integration' rather than 'design from nowhere'"* (Rönkkö et al., 2008, p. 71). That is, a better fit between technology and use, and promote user satisfaction and efficiency (Bjerknes & Bratteteig, 1995; Kensing & Blomberg, 1998). But what factors enabled and constrained such participation when developing a data entry interface in a generic software package in Uganda? Fischer (2008) and Roland et al. (2017) argues that the architecture of such generic systems need to provide flexibility or 'space' for customization to support user participation in design. Moreover, a variety of organizational factors are argued to be relevant to the utilization of this flexibility. Based on the interface development processes outlined in the results, this section will answer the research question of this thesis by analyzing and discussing factors that might have influenced the 'space' for customization and end-user participation.

Three technical and five organizational factors have been identified and will be discussed. Each factor is reliant on, and interconnected with other factors, but combined they help illustrate the complex socio-technical nature of user participation in such projects. The factors are summarized in Table 6-1 and discussed in more detail in the following sections. After outlining each factor, examples of how these may interact and depend on each other is provided.

Examples from the design process of the two interfaces in WAOS will be used, from here consistently labeled *phase one* (using built-in data entry tool and evaluation with one expert) and *phase two* (developing web-app with several health workers involved in the design process).

Table 6-1 Enabling and constraining factors for user participation

	Technical factors		
1	Capabilities for customization		The software provides flexibility to support customization. Three types have been identified:
		Built-in capabilities for customization	The software includes built-in tools for customization of some aspects of the interface.
		Modular apps	The software architecture enables development of customized modules.
		Open source software license	The software license enables modification of the source code to customize the software.
2	Dependencies		Capabilities for customization provide flexibility to support local customization although it is shared as a common software instance with other health programs.
3	Ease of mastery		Capabilities for customization are easy to learn and utilize.

	Organizational factors	
1	Project autonomy	The implementation initiative is provided with autonomy from other national implementation projects and the global development of the software.
2	Motivation	Involved actors are motivated to engage users in the design process.
3	Time and financial resources	Project has time and financial resources available to engage users in design.
4	Competence	There is competence on 1) methods and techniques for user involvement, and 2) utilizing available technical flexibility.
5	Participation culture	The organizational and political-cultural context enable health workers and other facility personnel to participate in decisions.

6.2.1 Technical Factors

'Room for alternative technical and/or organizational arrangements' is outlined by Clement and Van den Besselaar (1993, p. 31) as a fundamental requirement to enable user participation in design. Thus, the software has to provide flexibility for customization to respond to local requirements derived from user participation (Bansler & Havn, 1994; Dittrich, 2014; Kimaro & Titlestad, 2008; Roland et al., 2017; Titlestad et al., 2009). According to Fischer (2008), this technical flexibility can be pre-designed into the software as built-in tools for customization, by providing open Application Programming Interfaces (APIs) to build modular apps, or by enabling configuration of the software code through open source software licenses.

In the WAOS project, three technical factors are identified as prominent in shaping the space for user participation in design. These are; 1) available **customization capabilities**, 2) **dependencies**, and 3) the **ease of mastery**.

Technical Factor 1: Customization Capabilities

Customization capabilities are available tools in software that enable customization of functionality and user interfaces. Three types of customization capabilities can be identified in DHIS2, each providing a certain degree of design flexibility:

1) **Built-in tools for customization** enable the local developers or implementers to configure the user interface. These tools can provide a varying degree of design flexibility. In DHIS2 this is provided by the *standard form*, *section form,* and *custom form* tools.
2) **Modular apps** enabled by open APIs where developers can create additional modules to the software (often labeled *web-apps* or *third-party apps*), free to design the interface

in any way, only mildly constrained by the functionality and structure provided by the underlying software/platform core.

3) An **open source software license** which allows developers to modify the source code of the software to do extensive customization beyond the limitations of built-in tools and modular web-apps.

Being designed as a platform, DHIS2 provides these customization capabilities through different layers in its architecture. Built-in tools are provided to customize standard interfaces, web-based modules can be developed using the API, and the open source license enables developers to change the platform core if desired.

In the phases of the project, two types of customization capabilities were utilized. In phase one, the built-in *custom form* tool was used to make minor adjustments seen as sufficient in providing a minimum fit between the system interface and the particularities of the commodity ordering domain and their established work routines. The second phase utilized the modular architecture of the DHIS2, by developing the interface as a modular app that provided extended flexibility to respond to user's ideas and challenges. The combination of the DHIS2 API and web-based programming languages and HTML5 functionality proved to provide a highly flexible space for innovation based on user involvement. For example, the data entry process could be drastically redesigned, and offline capabilities defined by the HTML5 standard made it easy for the developers to respond to the issue of unstable internet connection.

To summarize, Figure 6-1 provides an illustration of how each capability for customization offers an increased level of design flexibility.

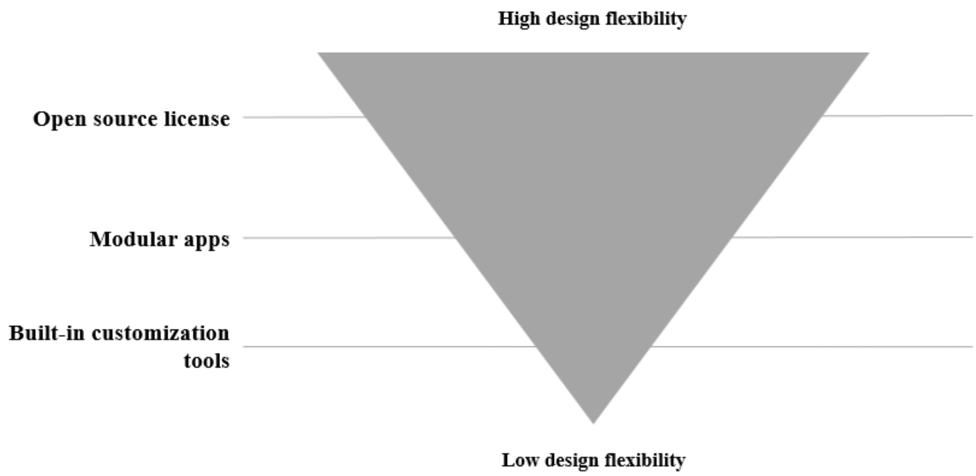


Figure 6-1 Customization capabilities and flexibility

Technical Factor 2: Dependencies

Each customization capability provides flexibility to change the generic software. However, as seen, WAOS was implemented as a ‘cloud-based’ solution on the existing national DHIS2 instance already serving other reporting regimes related to other programs and domains. This means that these implementations share one common DHIS2 software instance running on a national server. For a new health program that wants to customize their interface, it is therefore relevant whether utilizing a customization capability would affect existing implementations on the server. Based on this, the capabilities outlined in the previous section can further be categorized as *dependent* or *independent* from existing implementations.

Fischer (2008) argues that modular architectures enable change in individual parts, without affecting shared components. Figure 6-2 provides an illustration of how the independent customization capabilities enable new implementation initiatives to customize without affecting or coordinating with existing implementations (left). This is enabled by providing loosely coupled modules that each program can customize independently. To the right, we see how dependent customization capabilities that change elements in the core of the shared software instance lack this flexibility.

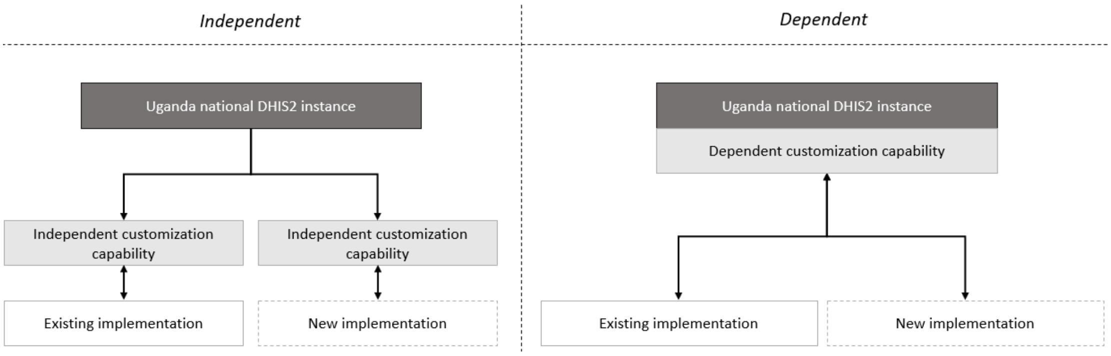


Figure 6-2 Independent and dependent capabilities

By being loosely coupled from the software core, both built-in tools for customization and modular apps can be utilized independently of the existing instance. By using independent customization capabilities in both design phases of WAOS, the local development teams could customize and develop their specific part of the DHIS2 system to suit the use case, without interrupting or coordinating with other existing programs using the national DHIS2 instance. Thus, functionality was implemented without concern for how the core was developed and maintained.

In contrast, modifying the software core by utilizing the open source license can be seen as a dependent customization capability. Here, the inner workings of the core implementation have to be considered, and changes are required to be coordinated with existing programs. Thus, this was not an attractive option in the case of WAOS as this coordination would have introduced complexity by coupling the specific project tighter to other ongoing projects, which is further discussed under the organizational factor ‘Project Autonomy and Flexibility’. So, while modifying the software core provide the highest degree of flexibility, it might be constrained by its dependency on other health programs.

Technical Factor 3: Ease of mastery

Another factor that is relevant to the actual utilization of flexibility provided by the customization capabilities is their ease of mastery (Fischer, 2008; Kimaro & Titlestad, 2008). For example, the ease of mastery of the built-in tools for customization determines to what degree the functionality for design it provides is used by the developer. For DHIS2, the interface for built-in form design is designed to enable implementers with little or no programming background to do customization (Kimaro & Titlestad, 2008). The modular architecture manifested in the API and web-app uses established web standards to enable developers with basic web programming skills to utilize its potential. Both are supported by extensive documentation openly available online, providing step-to-step guides and examples of use. Further, by using established web standards, the web-apps can be built using popular frameworks such as AngularJS and React. Finally, by requiring more advanced programming skills, utilizing the open source software license to change the platform core provides the least ease of mastery. However, to lower this barrier, the inner workings of the platform core are also described in the open documentation, and the software code of the core itself is modular in nature.

In the two phases, the customization capabilities’ ease of mastery was a part of the discussion. By using ‘custom form’ in phase one, customization was easier and less time-consuming. In phase two, as the development of a custom app is related to less ease of mastery, it implied that more competence (discussed as an organizational factor in the next section), and time to read the documentation and attend a DHIS2 academy in Rwanda was required. Therefore, time for actual development increased by using this capability.

With customization capabilities and their dependency and ease of mastery in mind we now turn to the organizational factors that might further affect the utilization of the underlying technical flexibility.

6.2.2 Organizational Factors

As we see, technical flexibility in the software provides a space for customization based on user participation. However, it is not given that this potential is utilized within a project. As discussed by Fischer (2008), Dittrich (2014), Titlestad et al. (2009), and Roland et al. (2017), for technical flexibility to be utilized, various factors of organizational nature are of relevance. A social architecture or 'scaffolding' with 'boundary spanners' (Titlestad et al., 2009) that mediate between developers, end-users, health professionals, and other actors need to be established. The literature mentioned mainly focus on mechanisms for large-scale participation from individual projects to the core development of the generic software. As the research topic of this thesis is concerned with participation to affect the design of data entry interfaces in a specific implementation project, the factors discussed here will be focused on enablers and constrainers on the local project level.

A social scaffolding surrounding the DHIS2 software was in place in Uganda, enabling local development and implementation of the software. Local boundary spanners were present through the local node, HISP Uganda, which entailed technical competence of DHIS2 and contacts in the Ministry of Health. However, in phase two, the boundary spanning, or mediation had increased focus on including the local end-users in the design process. Based on Titlestad et al. (2009, p. 18), Figure 6-3 illustrates how the implementer in both phases mediated between local and global developers and national managers within the health domain. Moreover, the mediation in phase two also focused on local end-users (marked with dashed arrow line). In both cases, the implementer also functioned as a local developer.

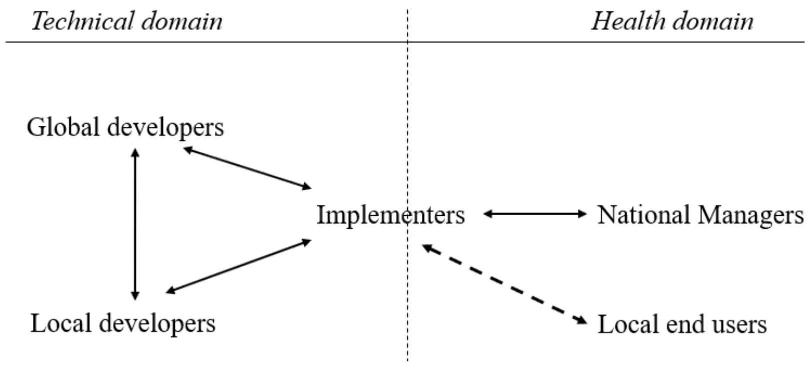


Figure 6-3 Implementer as mediator in the case

From the empirical case, we can identify several aspects that affected the utilization of customization capabilities, hence shaping the local *space* for participation in the two phases.

First, the global software development project needs to provide local implementation projects with autonomy and flexibility to respond to local and project-specific requirements. Further, the project stakeholders need to be motivated to include users in the design process, and have time and financial resources available. If decided to involve users in the design process, boundary spanners need to possess competence on how to utilize the customization capabilities of the software, and on user involvement in design. This process might, in turn, be constrained and enabled by the participatory culture of the organizational and political context. Again, it is emphasized that these factors are interlinked and dependent on each other. Following is a discussion of each of these factors followed by examples of how they work together.

Organizational Factor 1: Project Autonomy and Flexibility

By using the generic software package DHIS2, the WAOS implementation initiative was part of a larger software development project. If this local implementation had been fully reliant on the core developers of DHIS2, or entirely controlled by a goal of developing generic functionality and interfaces, the ability to respond to specific needs would have been constrained. Further, with a cloud-based centralized server solution where the implementation was reliant on a common instance of DHIS2 serving a variety of health programs, dependency to national implementation and maintenance of this instance might constrain the available flexibility. Thus, to enable the local implementation project and end-users to 'take an independent position to the problems' (Kensing, 1983, p. 223), and to provide 'room for alternative technical and/or organizational arrangements' (Clement & Van den Besselaar, 1993, p. 31), the social architecture needs to provide local autonomy from the:

1) Global level: The global software development project that develops the generic software application.
2) National level: The national maintenance and development project that run the centralized software instance to be used.

The customization capabilities of DHIS2 form a basis for this autonomy. All three capabilities outlined in the previous section provide flexibility to deviate from the global software development project in that customization can be done without coordinating with core developers. However, dependent capabilities may be constrained by the national maintenance and development project since it might affect existing implementation on the common DHIS2 instance. Thus, only independent capabilities provide flexibility to customize without coordination with the national maintenance and development project.

The existence of customization capabilities does, however, not guarantee utilization (Roland et al., 2017). The project also needs to provide local implementations with organizational autonomy. On a global level, instead of directly governing specific implementation projects, the core DHIS2 development team and HISP have established local autonomous nodes in the respective countries where the system is implemented and used (Titlestad et al., 2009). These nodes, such as HISP Uganda, possess the competence to utilize available customization capabilities and other relevant knowledge that enable them to initiate and maintain projects of implementations independently. Further, they have knowledge of, and credibility in both the HISP network and the local organizations where the software are implemented, making them boundary spanners that can mediate between the involved actors (Titlestad et al., 2009).

On a national level, flexibility from the maintenance and other implementations on the common DHIS2 instance was enabled by using independent customization capabilities. That is, by using built-in tools for customization (phase one) or developing modular web-apps (phase two). In this way, several local implementation projects with different developers are provided with autonomy and can customize individual parts of the same software instance without too much coordination.

Based on these aspects, we can see an interaction between system architecture, governance, and local autonomy, in that flexible technical architectures enable flexible and distributed development and implementation, and that the way HISP and DHIS2 are governed have shaped the architectural traits of the DHIS2 platform (as briefly described in Chapter 2).

Figure 6-4 illustrates the levels of governance and autonomy in this project. The global DHIS2 software development project provides a generic software solution, and the Uganda national DHIS2 maintenance and development project customized this to run as a national instance, providing HIS functionality to a variety of reporting regimes in the country. The local implementation initiatives building new reporting systems based on this centralized DHIS2 instance can customize user interfaces and functionality through the provided independent customization capabilities that are loosely coupled with the software core. Each project level is relatively autonomous, but shares knowledge and experiences through the HISP network. Moreover, these experiences are used by the global DHIS2 development project to further develop the generic DHIS2 software, and by the other levels to strengthen local competence on implementation (Roland et al., 2017).

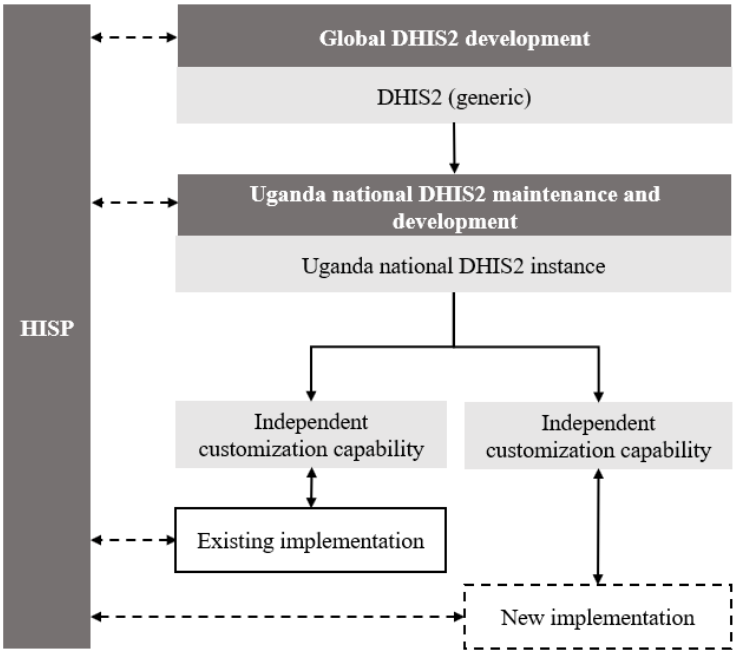


Figure 6-4 Governance and project flexibility in the case

Organizational Factor 2: Motivation

Provided with sufficient autonomy, local implementation initiatives further have to be motivated to engage users in the design process. This motivation is reliant on factors such as the aim of the project, available resources, and the awareness of the possible benefits it might have. Further, this motivation must be entailed by actors such as the system implementation lead (such as HISP Uganda), the system developers, and in the organization that are to use the system (such as Ministry of Health and health facilities). In resource-constrained projects with a limited awareness of possible benefits, it has proven challenging to motivate the various stakeholders to invest in user involvement (Kyng, 1994). This is understandable since initiating such initiatives requires a significant level of resources and commitment by the involved parts as seen in phase two of the case.

First, motivation is affected by the aim of the project. This aim can vary between the involved actors. For example, the system implementation lead and developers, such as HISP Uganda and the overall HISP project can see the aim as to produce a generic solution that can benefit the global HISP and DHIS2 community. The user organization, for example Ministry of Health, can be interested in a system that fits the particularities of their organization but provided within a limited amount of resources. As seen in the empirical case, with the aim of contributing to the broader HISP community, HISP Uganda attempted to avoid making the interface too specific. So, in phase two, the process started with a debate on whether to support local requirements or creating a generic solution. The HISP team argued strongly for a generic solution while Ministry of Health wanted the interface to be specific to local practice. The decision to make a specific solution obviously had a significant impact on the relevance of direct user involvement. Hence, such aims must be aligned through negotiations. The agreement reached will either enable or constrain the relevance and ability to involve users in the design process. In the phases of the case, the aim was also different in that the first interface was designed as one part of a larger digitalization project. In addition to data entry, developers and implementers had to focus on a variety of aspects, such as the underlying data structure. In phase two, the aim was narrower and based on issues identified in the previous design.

Secondly, awareness of the possible benefits of involving users in data entry interface design must be present. To stimulate motivation, information on these benefits need to be a part of the discussions between involved actors, where the boundary spanners could play a leading role. In the first phase of this project, user involvement in the design of the data entry interface was not a part of initial project discussions and planning. In phase two, the assumption that user involvement would provide benefits founded the very basis of these discussions. This assumption was for one based on learnings after implementation in the first phase, where issues were discovered. This increased motivation to investigate the established routines of end-users more thorough. Also, the participatory methods to do this investigation was introduced and emphasized by me as a way of ensuring a better fit between the interface and existing practices. Hence, the combination of learnings from phase one, and a mediator which promoted user engagement affected aim and motivation.

Third, time and financial resources are relevant to motivation and will be discussed in the following section.

Organizational Factor 3: Time and Financial Resources

As seen, a significant amount of time and resources is required to involve users and to utilize customization capabilities of the software. Thus, resources need to be available in 1) the project to spend time on design processes and development, and 2) in the organization that is to use the system, to enable health workers and relevant personnel to participate.

Enabling easier configuration of the software, customization capabilities with more ease of mastery will require less time and resources invested in technical development. In phase one of this project, using the built-in tools for customization enabled less resource consuming development. Further efficiency was achieved by limiting user engagement to an expert from the Ministry of health. The design process of the second entry interface required considerable time for developers, designers, and the participating users. It can be argued that this unfolded in a *greenhouse setting* (Kensing & Blomberg, 1998), where the research project provided a protected environment with extended resources for participant access, design and user-involvement, and software development. In implementation initiatives that are not part of such protected research settings, available resources might be severely constrained. A balance between the level of user involvement and customization, and the use of resources need to be weighed against the possible benefits. This will ultimately affect the choice of customization capability, the number of users to engage, and the numbers of iterations of prototyping and user evaluation.

Further, the organization that is to use the implemented system also need to have available resources for health personnel to participate in the design. In phase two of this project, it was found that user participants were already overloaded with health-related work, and the methods of user engagement had to adapt. For example, gathering several participants from different facilities in a joint workshop proved to be difficult. Instead, facilities had to be visited one by one, limiting the amount of time required from the participants to be a part of the process. In turn, this was more resource consuming for the implementation project. Also, it made user interactions fragmented, making my role as a mediator even more important.

Organizational Factor 4: Competence

In addition to awareness of the benefits of user involvement, the project needs to possess competence of *"[...] 'contextual' techniques [that] help to better understand users' working environments."* (Hess, Offenberg, & Pipek, 2008, p. 32). This is related to the fourth requirement of Clement and Van den Besselaar (1993, p. 31) 'the availability of appropriate participatory development methods' in that the availability of such methods are partly determined by the projects ability to put these into practice.

In other words, a boundary spanner able to communicate with health workers and other relevant actors needs to be available to build mutual understanding between developers, domain experts, and end-users. Means of communication include traditional participatory design methods, as discussed by Kensing and Blomberg (1998), which was used in the second phase of this project (described in Chapter 3.3). This includes contextually relevant social skills, how to structure the overall process (e.g., use-oriented design) and techniques such as workshops, focus groups, prototype evaluation and so forth. From the case, we can see that this competence was strengthened in phase two as I had experience with such approaches.

Further, technical developer competence determines which software customization capabilities that are available. As discussed, the three types of customization capabilities presented here is related to a varying degree of ease of mastery. For a DHIS2 implementer to use the built-in customization tools, some knowledge of the software and some web programming competence are needed. To develop modular apps, programmers with more advanced skills need to be available. Finally, modification of the platform core requires high-level software development competence. In phase two, building a modular app required extended competence to utilize the flexibility provided. Figure 6-5 illustrates how each customization capability is associated with ease of mastery and level of technical competence required.

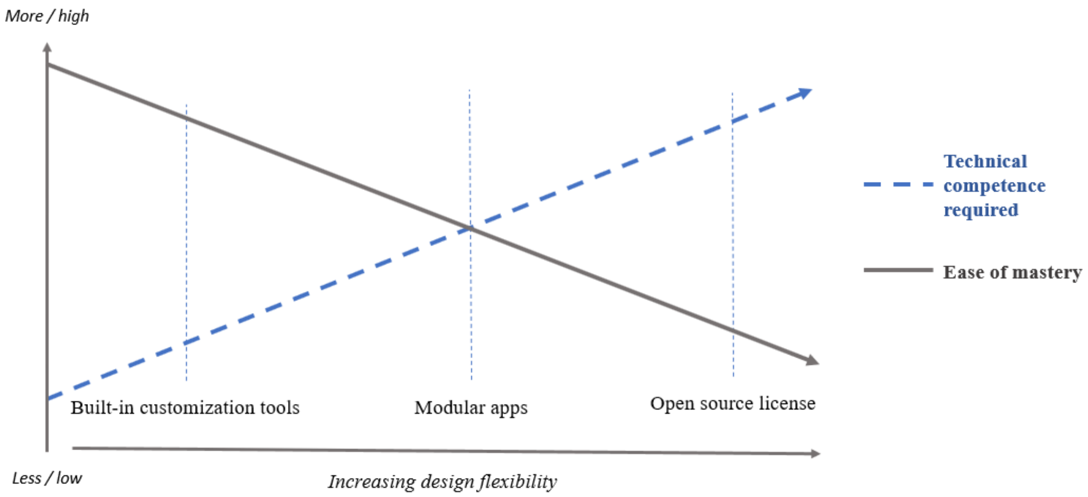


Figure 6-5 Ease of mastery and competence

As seen in the second phase of this project, prototyping was an essential part of the design process when building a modular app, as it does not provide any preconfigured interface to base the discussions on. These prototypes were designed to enable communication of ideas and design aspects between user participants, developers, and other stakeholders. At first, basic paper sketches may be sufficient and beneficial in drafting early ideas. As the fidelity increases, skills to create more detailed and interactive prototypes will often be required. Kimaro and Titlestad (2008) argue that built-in tools for customization provide a low-barrier way of creating such high-fidelity prototypes in that easy configuration in the system enables rapid, but detailed prototyping. In phase one of this project, this was utilized when designing the interface with an expert from the Ministry of Health. However, these tools might constrain possibilities and scope of ideas for design (Titlestad et al., 2009). As seen in phase two, more flexible customization capabilities were utilized to avoid this. Without using predefined tools, external prototyping tools such as wireframes may be necessary to rapidly respond to user feedback. These can later be implemented as a web app module or in the core of the actual platform, after various aspects of the design has been evaluated with users. Thus, as extended design flexibility means less predefined design tools, a project utilizing such capabilities would be more reliant on a boundary spanner with competence on methods and techniques on user involvement to be able to communicate ideas between involved actors.

Organizational Factor 5: Participatory Culture

Finally, the organizational culture might constrain access to users, and their ability to participate in actual decisions. One can argue that Kensing's (1983, p. 223) three requirements for participation, that participants need to be provided with 'access to relevant information', 'the possibility for taking an independent position on the problems', and 'participation in decision making', are all dependent on cultural factors stemming from the organizations involved and the political climate and culture of the overall country. Being suited for a research topic worth a thesis of its own, discussing the application of concrete methods and techniques for participation in specific cultural contexts is beyond the scope of this thesis. However, as an essential enabler and constrainer of participation in data entry interface design, some reflections on how these factors affected this project is provided.

As mentioned, factors constraining the participatory culture might stem from several levels, such as; 1) the contracted developer organization that will develop the system (HISP Uganda), 2) the contractor organization that will use the system (the public health system/health program), and 3) the overall cultural context of the country or the region (Uganda, East Africa).

First, the contracted organization in charge of development and implementation (HISP Uganda in our case) might have some cultural norms and traits that affect user participation in design (Heeks, 2002). For example, software developers may doubt the value of user feedback, arguing that their technical knowledge is sufficient. Developers are known to be hesitant to engage users in design, and in the words of Hess et al. (2008, p. 33) "*resist[ing] to contributions from external stakeholders*". Here, one can argue that motivation and competence on user involvement within the development team are essential for creating the right cultural conditions to promote participation.

Secondly, the methods used for user engagement, in this case, have its origin in Scandinavia, and other Western countries (Kensing & Blomberg, 1998). There is a body of literature discussing the applicability of Participatory design methods in organizations in developing countries due to cultural differences (e.g., see Hussain, Sanders, and Steinert (2012); Puri et al. (2004); Winschiers (2006)). The organizational culture of the contractor or organization where the system is to be implemented and used (the public health system in our case) must provide the developing organization access to relevant users, and enable their health workers to express their critical thoughts to participate in actual decisions. In organizations where systems are typically designed based on the need of managers, active measures must be taken to communicate potential benefits of involving health workers at the other end of the hierarchy, and in ensuring that participants feel comfortable with criticizing established and planned systems.

Third, the overall political-cultural context might introduce constraints that affect both prior levels. As user participation in design, especially in the form of participatory design, often emphasize shared decision-making based democratic values, the established culture of countries that have a less democratic model of governance in other areas of society, and/or are based on stronger hierarchical structures, might constrain participation (Puri et al., 2004; Winschiers, 2006). For example, reporting from a participatory design project in India, Puri et al. (2004) argue that the strong hierarchical structures embedded in the culture on a national level constrained the participant's ability to participate in actual decisions. Here, the methods of participation had to be adapted to these circumstances for user involvement to be of value. Similar challenges have been reported by Sæbø and Titlestad (2004) in a HIS project in Cuba, where the overall political context and a strongly centralized health system provided challenges meeting traditional participatory techniques.

In phase two of the project from Uganda, experiences were that methods and techniques for participation proved fruitful in reaching the goal of a more informed design, suited for local practice. When I promoted user participation as beneficial, both Ministry of Health, the local HISP node, and health workers and managers at all levels of the system proved to be highly supportive of the participatory approach. Cultural issues were mainly related to practical execution, such as planning of focus groups and meetings, and of promoting real critique of design suggestions were present. In line with Puri et al. (2004), these challenges were overcome by adapting the participatory methods used, and by being pragmatic and flexible, taking advantage of the opportunities that emerged, and adapting to the local customs of time, language, and social structures. However, my role as a mediator between the involved actors might have played a part in gaining access to facilities, enabling the users to express critical feedback, and making sure that this feedback actually affected the design of the interface. In the following section the factors just outlined are summarized, as well as how they interact and play a role in the two phases of the case.

6.2.3 How the Factors Interact to Form a 'Space'

We can see that the space for user participation in our case was formed by a variety of technical and organizational factors. On the technical side, *customization capabilities* in DHIS2 provided alternatives with various levels of flexibility to respond to learnings from user participation. The capabilities' *dependency* to the software core and the *ease of mastery* of these capabilities partly determines the actual use. Organizationally, the level of *project autonomy* of the implementation project from global and national development and maintenance formed the degree of flexibility and constrained available customization capabilities. Further, the *motivation* for user involvement in design, largely determined by the aim of the project and awareness of possible benefits, had an enabling and constraining effect in the two phases of the case. With lack of awareness of benefits or an aim of making generic functionality, motivation and the relevance of including users in design might be limited.

As user involvement implies a process that requires more time and other resources, sufficient *time and financial resources* need to be available. If the project is motivated to engage users and resources are available, *competence* on methods and techniques for user involvement needs to be present. Competence on how to utilize the technical flexibility through the customization capabilities are moreover needed. The level of competence required here is also related to the ease of mastery of the capabilities available. Finally, the organizational and political culture where the project is operating needs to provide a *participatory culture*, that enables user participants to take part in decisions. Figure 6-6 illustrates how the technical flexibility and organizational capability for utilization together form the available space for user participation.

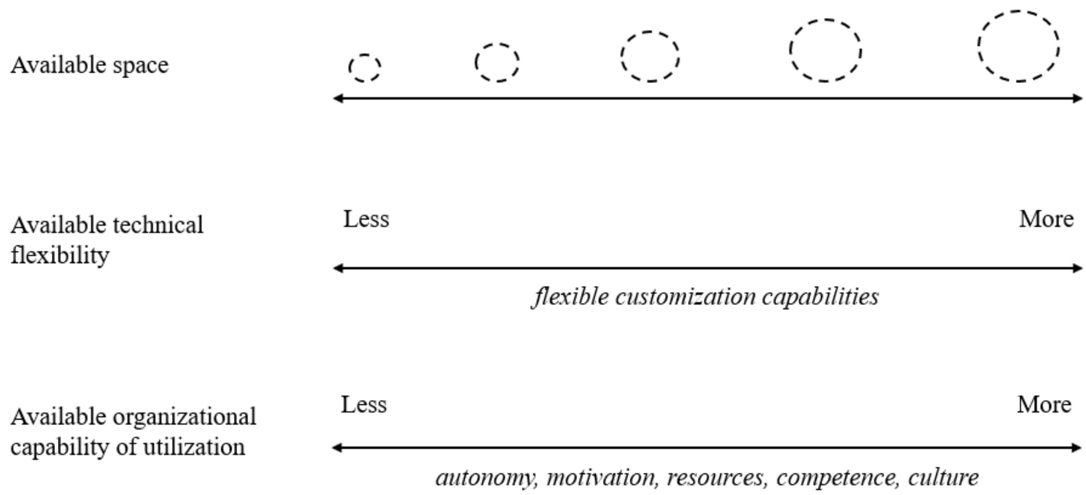


Figure 6-6 Factors that enable and constrain the space for user participation

We can further see that several of these factors interact and are dependent on each other. For example, the autonomy of a project might be reliant on financial resources, the technical flexibility of software, technical dependencies, and competence within the project. Also, motivation might be reliant on the available time and financial resources, and competence. Moreover, the level of competence needed could be related to the participatory culture and the customization capabilities of the software and their ease of mastery. The utilization of these capabilities might again be affected by time and resources available.

Level of Participation and Space

In phase two of this project, it was attempted to involve users in fundamental decisions regarding the structure and process of ordering in the digital interface of DHIS2. As seen in chapter 3, user participation can be more or less extensive. Damodaran (1996) describe a continuum where the level of participation can vary from informative, consultative, and participative. While Participatory Design is close to the participative end of the spectrum, other approaches to participation may be less concerned with user participation in fundamental decisions, and rather involve users to evaluate minor decisions, or only to build a better understanding of their work (Kujala, 2003). The needed space is thus determined by the aim and approach taken to user involvement. This will, in turn, affect the required technical flexibility and organizational capability needed for utilization (Figure 6-7). For example, less flexibility in customization capabilities is needed if the goal of involvement is more informative. By aiming to involve users in more fundamental decisions during phase two of the case, a customization capability with more flexibility was required. Moreover, the time and competence needed when only involving users in minor evaluations of particular aspects are much more limited than when aiming for a more participative level of engagement. This regards both competence for technical utilization and methods for user engagement. Also, informative or consultative approaches might be less constrained than participative approaches in challenging participatory cultures (Puri et al., 2004).

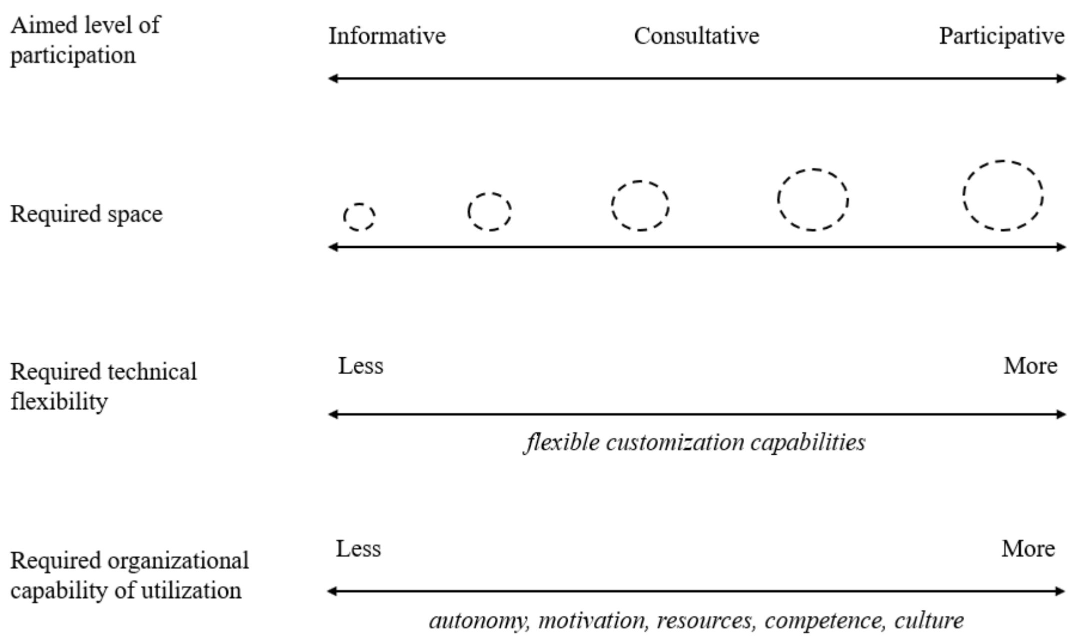


Figure 6-7 Relation between the level of participation, space, and enablers

In turn, as described, the space created by technical flexibility and organizational capability for utilization of this will affect the level of user participation possible in the project. Greater flexibility and capability creates a larger space, which allows processes that are closer to the participative end of the continuum. For instance, due to cultural challenges and time constraints in phase two, participants had to be engaged in a distributed nature. These constraints might have pushed the process towards consultative, even though the aim was participative user engagement.

In sum, we can thus see a two-way interaction where required space is determined by the aimed level of participation, and the available space created by the technical and organizational factors affect the potential level of participation (Figure 6-8).

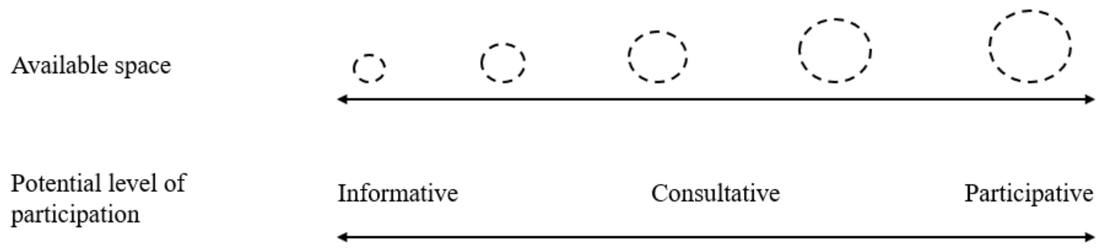


Figure 6-8 Space and potential level of participation

Explaining the Differences in the Two Phases

With these three technical, and five organizational factors in mind, we can look at the two phases of the empirical case, trying to explain the different level of user participation. Both phases used DHIS2 and were provided with the same customization capabilities and technical dependencies. HISP Uganda possessed developers with competence to utilize both built-in tools for customization and modular web-apps, although the latter was limited to only a few developers. Phase two benefitted from extended time and financial resources, hence, time and resources might have played a role in the choice of using built-in tools in phase one, and building a modular web-app in phase two.

HISP Uganda was responsible for implementation and was in theory provided with the same project autonomy in both phases. However, the extended time and financial resources provided by the research project might have decreased reliance on financial support from Ministry of Health as a contractor, and the global HISP project, increasing project autonomy. This might have affected the project aim, in that developing something more specific than generic was more feasible.

Awareness of benefits of user involvement is relevant to motivation. My part in promoting user participation as an enriching part of the development process to the involved actors played a significant role in the decision to involve users. Further, competence on methods and techniques for user involvement was strengthened in phase two, as I had experience with this from previous projects.

The participatory cultural context was to a degree the same in both phases. However, my presence as a mediator between Ministry of Health, HISP Uganda and the user participants might have played a role in enabling or constraining the participants actual ability to be involved in decisions, and that these decisions were implemented in the prototype.

In sum, it seems that the extended resources following the research project and the extended competence and motivation for user participation were prominent factors in determining the degree of user participation. In the following section, some reflections on how this can be strengthened are provided.

6.2.4 Promoting Participation

Titlestad et al. (2009) argue that implementers can function as boundary spanners between developers and domain experts. In this empirical case, we can see that the implementers in phase two had increased focus on mediating with local end-users that were affected by the data entry interface. The implementers leading role in this suggests that strengthening competence on user involvement and providing the scaffolding that supports this can increase the space by enabling utilization of available technical flexibility. Based on differences in the two phases of the case, it can be argued that further strengthening of the HISP scaffolding should emphasize facilitating arenas within the specific implementation initiatives where national managers, local end-users, and technical developers build a mutual understanding when designing interfaces. This process will be reliant on a mediator that can communicate benefits, execute participatory processes, and ensure that health workers are able to impact relevant decisions, without being dominated by national managers or technical experts. To summarize, Figure 6-9 illustrates how implementers could attempt to create a shared arena where all actors, and especially local end-users and developers can build a mutual understanding through several iterations of workshops, prototyping, and evaluations to emphasize informed data entry interface design.

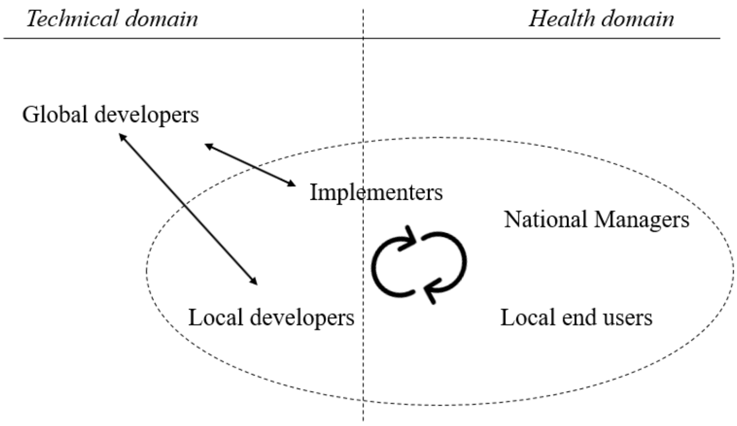


Figure 6-9 Implementers as facilitators of participation

Building Competence

As argued, motivation and competence were two factors that might have constrained user participation in the first phase. Knowledge of the possible benefits of user participation in design could affect the motivation to do so, and competence on methods and techniques are essential to execute the process. How can this be increased? It takes time and practice for developers and computer experts to learn to put their own preferences aside and listen to the users. Thus, it has become common for educational institutions in western countries to provide courses that enable students to acquire an appreciation for the value of user participation in design and learn tools and techniques (Kensing & Blomberg, 1998). Increased focus on this topic in local competence building could promote user participation in digital data entry interface design. The established DHIS2 academies already provide an arena for knowledge sharing and learning for new implementers and developers. This might be an arena to introduce benefits and basic principles and techniques on this topic.

Having answered the research question by analyzing and describing technical and organizational factors that influenced the space for participation in the empirical case, we shift focus to a related discussion of the possible benefits user participation might have in relation to the overall goals of HIS strengthening.

6.3 Possible Positive Outcomes of User Participation in the Design

We can see the participatory project in phase two of this empirical case was concerned with Gärtner and Wagner's (1996) Arena A; the design of specific systems and creation of new organizational forms. The goal was to address the challenges identified in the existing system by developing a new entry interface through user participation in design. Literature presented in Chapter 3 relate computer interfaces (Gasser, 1986; Kensing & Blomberg, 1998; Kujala, 2003) and data collection tools (Lippeveld et al., 2000) to several of the issues found in this case. Although the prototype developed through the design process has not yet been implemented, and statistical evidence of improvement is lacking, some qualitative indicators of improvement found in the evaluation phase will be discussed here. Four outcomes have been identified: 1) better fit between technology and use, 2) increased technology acceptance and work satisfaction 3) improved data quality, and 4) promoting integration. These outcomes and their relationships are summarized in Figure 6-10 and discussed in further detail below.

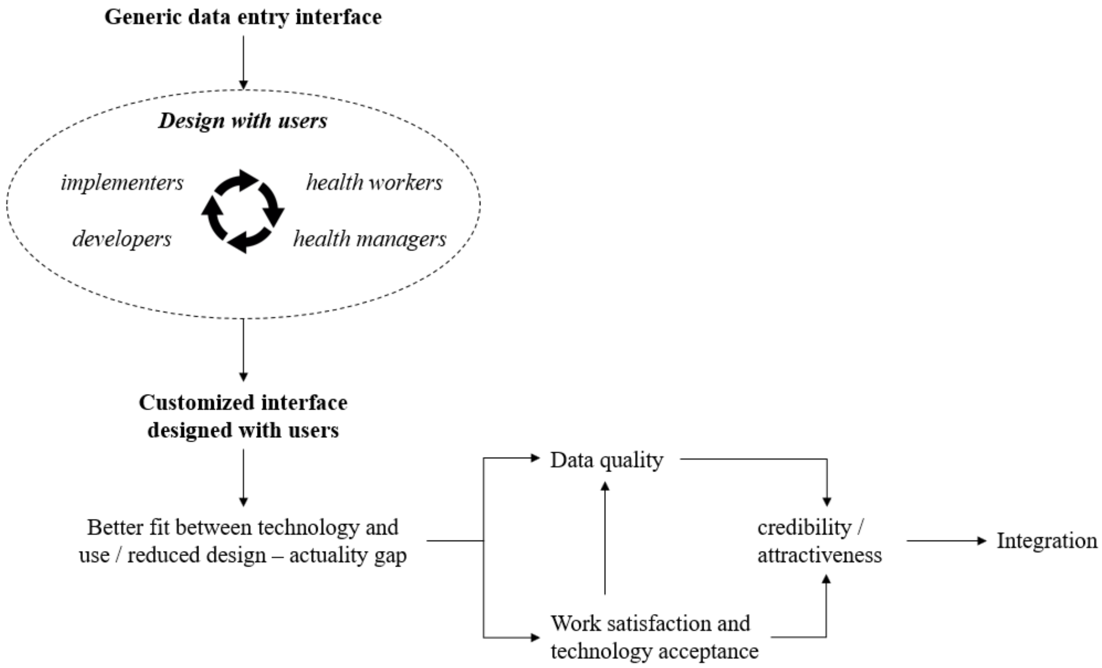


Figure 6-10 Possible outcomes from user participation in data entry interface design

6.3.1 Providing Fit Between Technology and Work

In the first phase, user evaluation and participation in design were lacking, except minor evaluations with a manager from the Ministry. The diagnostic phase revealed that the interface was not sufficiently adapted to established work practice. While the expert evaluation ensured that the most basic requirements were covered, it seems as this did not provide enough insight to develop an interface that sufficiently supported the final users. One can argue that this distance between design and use extended the design-actuality gap (Heeks, 2002) which resulted in the challenges related to burden, clarity, and layout of the digital form.

As in phase one, the developers in the second phase had limited knowledge of the domain and use context. However, in line with Lippeveld et al. (2000), and literature on implementation of computer systems in work settings (e.g., Kujala, 2003), user involvement was emphasized to build this understanding. Following principles from the tradition of Participatory Design (PD), users were engaged throughout the design process, in everything from identifying problems, generating ideas, and evaluating concrete design suggestions through prototyping. Through this process, users made decisions about the design, and the developers gained knowledge of the domain, users, and context, which enabled design with improved *fit* with existing work practices. Thus, an active attempt to minimize the design–actuality gap. The final evaluation of the prototype indicated that clarity had been improved significantly.

6.3.2 User Acceptance and Work Satisfaction

Data entry personnel and health workers consistently expressed great discomfort in using the data entry interface of WAOS. As described in Chapter 5, one participant emphasized the fatigue associated with data entry; *"you see, the fatigue associated with working on a screen overloaded with information is huge [...]"*.

One of the primary goals of the PD tradition has been to improve work satisfaction and technology acceptance among the workers that use the technology implemented (Bjerknes & Bratteteig, 1995). This acceptance at the point of data collection is relevant to the success of HIS strengthening, in that motivation by the health workers is key to promote timeliness, quality and data use (AbouZahr & Boerma, 2005).

User participation in the design of the new prototype provided an arena to not only discuss functional requirements but also to let the users test concrete design suggestions and provide ideas and feedback on how it would support their work in a *pleasant* matter. This in line with one of the main aims of user participation; to support the users through how they *"[...] (want to) perform their work"* (Kensing & Blomberg, 1998, p. 168). Considering this, the step-wise data entry screen provides improvements, not limited to potentially increased data quality, but to the very work-comfort of the user. This is especially relevant for the personnel at the paper-to-computer gateways, which use this interface daily. During the final evaluation, several participants reported that the prototype had the potential to improve their work day and that they were welcoming implementation.

The Issue of Power Balances

As seen in Chapter 4, Participatory Design has traditionally put emphasis on power balances (Gärtner & Wagner, 1996). Participation is used as a tool to empower the worker in a setting where managers control and implement systems based on their needs rather than the workers'. In the case presented here, one can argue that the initial development of the system and interface had a strong emphasis on the needs of the managers, and was implemented by software developers with little concern for the health workers and data entry personnel. In the second phase, this group was provided the opportunity to voice their concerns and impact the outcome of development. From a critical view, the health workers' ability to participate in forming the technical artifacts of their work environment can be argued to be of intrinsic value.

6.3.3 Data Quality

Several participants in the diagnostic phase of this research reported that lack of clarity in the data entry interface of WAOS introduced challenges that might affect data quality. This is consistent with Lippeveld et al. (2000), which argues that clarity in the layout of the design is of great relevance to the quality of the data entered. In the case of WAOS, we can see that challenges have emerged due to elements in layout and structure of the data entry interface. Lippeveld et al. (2000) further emphasize the importance of involving health workers and data entry personnel in the evaluation of such instruments before implementation.

The prototype has as of the time of writing not been implemented for use, and there is, therefore, no quantitative evidence of improvement of data quality and timeliness. However, the qualitative evaluations with users indicate that ease of use and clarity of the collection instrument have been significantly improved, possibly solving some of the issues that were reported to negatively affect data quality.

6.3.4 Promoting Integration

As discussed, the commodity ordering system in Uganda is fragmented, with limited information sharing across disease-specific programs. To enable the combination of data from vertical reporting regimes to support improved forecasting and procurement, integration is a relevant agenda. As we saw in Chapter 3, top-down approaches to HIS integration is challenging due to the varying actor interests and distributed nature of governance (Braa & Sahay, 2012a; Nielsen & Sæbø, 2016; Sæbø et al., 2011). Braa et al. (2007) and Sæbø et al. (2011) illustrate how bottom-up approaches using an attractor can be a fruitful alternative. The attractor in their case is the DHIS2 software combined with flexible standards for data sets.

As seen in the empirical case, during meetings with representatives from the various programs, the WAOS and the prototype for a new data entry interface was discussed. Here, the underlying DHIS2 system provided an attractive alternative to the existing paper-based regimes of the other five programs. Since it had proven its success in providing the ARV-program with useful information, the program concerning Tuberculosis and Leprosy already was in the phase of planning implementation of the same system. By using the same DHIS2 instance, it was also argued that this would enable the desired comparison of information between programs.

However, a new attractive trait of the WAOS system was the prototype of the new interface that was being developed. Firstly, the design seemed robust and suited for what they knew of the conditions of the data entry personnel at facility and district levels. Secondly, information about the level of user involvement in design reinforced this argument and increased the credibility of the solution. This triggered arrangement of meetings with the laboratory program, where the benefits of the fit it provided with existing work practices were further discussed. This resulted in an agreement to plan for implementation of the very same solution in this vertical reporting regime.

What we see here can be argued to be an increased attractiveness of the WAOS solution, due to the data entry interface prototype, and the user involvement that had been a part of its development. This attractiveness promoted adoption by other vertical reporting regimes, which in turn might lead to increased integration. The data entry interface seemed to reinforce WAOS as an even stronger attractor.

Figure 6-11 illustrates how the prototype and the emphasis on user involvement in its design seemed to increase the credibility and value of the WAOS system, in that it would promote data quality, and user acceptance and satisfaction. In turn, this could lead to adoption by other health programs (Sæbø et al., 2011).

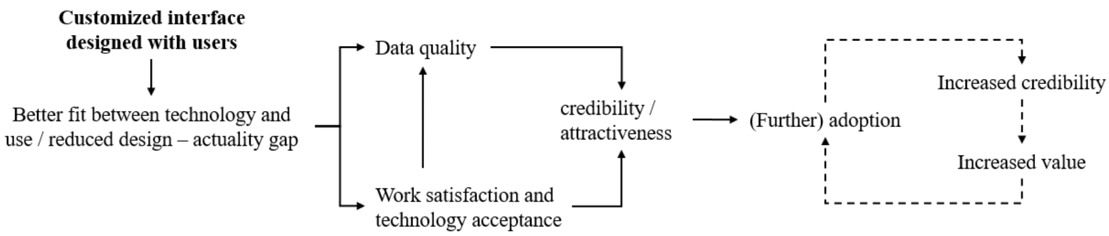


Figure 6-11 'Designed with users' as an attractive trait that promote further adoption

6.3.5 Summary and Reflections

Four positive outcomes of user participation in data entry interface design have been identified in this empirical case. Existing literature suggests that user participation leads to increased knowledge of use, making the design more informed, thus increasing fit between technology and established practices. In line with this, engaging users in phase two of this project proved fruitful to build a data entry interface with more clarity for health workers. Feedback from participants also indicated that the new interface might increase work satisfaction among the users. Moreover, in line with the Participatory Design tradition, empowerment of health workers to participate in forming the technology they use can also be seen as being of intrinsic value. As it was reported that data quality suffered due to unclarities in the existing interface, removing these unclarities might eliminate such issues and in turn, improving data quality. Finally, the attractiveness of adopting the WAOS for the other reporting regimes seemed to be strengthened with the new interface, possibly resulting in integration between health programs. We now turn to the final part of this chapter, which provides some reflections upon the research conducted in this thesis.

6.4 Reflections Upon the Research Conducted

In line with existing literature outlining requirements for user participation (Clement & Van den Besselaar, 1993; Kensing, 1983), in generic software packages (Bansler & Havn, 1994; Fischer, 2008), developed globally (Roland et al., 2017), in a developing country context (Puri et al., 2004), the research of this thesis indicate that space for participation is shaped by technical and organizational measures. It further provides rich insight on how mechanisms suggested by prior research are at play in a local implementation project, by outlining factors that enable and constrain local customization and engaging users in the process. It also supports claims of existing research on HIS data collection tools (Lippeveld et al., 2000) and user participation in information systems design (Bjerknes & Bratteteig, 1995; Kujala, 2003) that iterative design processes including users, experts and developers can increase fit between existing routines and digital design, thus providing increased clarity in data entry interface layouts. This section will reflect upon the research conducted and its implications for practice and future research.

6.4.1 Methods and Limitations

Action Research as an interventionist approach to qualitative research proved fruitful in exploring systems design and development processes in practice. Through a non-interventionist approach, such as case studies, similar knowledge might be derived but limited by learning from the articulated experiences of other subjects. Instead, by being involved in all aspects of the process, I personally gained a thorough understanding of the factors at play based on firsthand engagement with the problem. This means that my subjectivity as a researcher has influenced the documented findings. Here, the continuous discussions between all included actors such as HISP Uganda, Ministry of Health and the user participants, have been instrumental in ensuring a nuanced and rich picture of how the process unfolded.

The lack of quantitative data to support a claim of improved data quality limits the ability to conclude with actual improvement. Further, if qualitative evidence of improvement is provided at a later stage, the complex multivariate nature of the phenomenon of the study implies that no certain claims of cause and effect can be posed. For example, the improvements seen might be argued to be due to the extended time and focus on data entry interface design, rather than the actual user participation. However, as the involved developers had little knowledge of use context, and the design reflects specific aspects of established practice, it is reasonable to assume that this is not the case.

Moreover, the phenomenon of study and the exploratory and interpretive nature of this research implies that the factors identified provide limited ability for generalization to other implementation projects. My active role in development, generating data based on experiences, and in continuous hermeneutic analysis makes this process hard to replicate in detail by other researchers. To repeat Susman's (1978, p. 596) quote *"you cannot step into the same social system twice"*. However, in line with the interpretive research tradition, this is not the objective (for a thorough discussion of the scientific merit, value, and objective of interpretive research see Flyvbjerg (2006); Klein and Myers (1999); Walsham (2006)). Instead, the study has gained rich insight into one specific case of how such processes unfold under certain conditions. It has been attempted to provide a detailed account of methods for data collection and analysis, and a rich description of results and findings to enable other researchers to follow the arguments in the discussion. The implications of this research will be summarized in the following section.

6.4.2 Implications

In line with the goal of providing learnings of value both to practice and theory (Baskerville & Wood-Harper, 1996), this action research project has contributed both directly to the ongoing HIS strengthening in Uganda, the HISP project and the broader field of research on HIS strengthening and user participation in information systems design.

First, the practical learnings achieved through the prototype development phase is being taken further by HISP Uganda and new master students, hopefully contributing to the Ministry of Health's continuous efforts to strengthen their health commodity ordering and reporting systems. The prototype developed gives several concrete suggestions to a new layout for a data entry interface design based on existing work practices.

Secondly, by taking an active part in the use-oriented design process, HISP Uganda might have strengthened their understanding of why and how to involve users in data entry interface development. This may benefit other implementation efforts by this HISP node in the future, and experiences can be spread to other nodes in other countries throughout the HISP network. Moreover, the results and findings provide a basis to discuss 'best practice' and for further research on user participation in interface design in local implementation initiatives within the HISP research project.

Third, the factors identified as enabling and constraining for user participation in the design of generic software and large-scale projects in a developing country context provide rich insight to how this space can be utilized in local implementation initiatives. With the insights presented, findings from prior research have been further supported, such as Fischer's (2008) concept of socio-technical spaces for user participation, social architectures built and supported by boundary spanners (Titlestad et al., 2009), platforms as enablers of user participation (Roland et al., 2017), and data collection tool layouts as relevant to user satisfaction and data quality (Lippeveld et al., 2000). Moreover, rather than generating causal laws and predictions of future behavior in other cases, it can help develop a basis for 'best practice' in similar situations (Klein & Myers, 1999) in that it has improved the understanding of what *might* affect this space and enable or constrain utilization of software or platform flexibility. Although other factors may be found in other cases, it enables further exploration of this phenomenon. While the factors are interdependent and interact, they can provide the basis for future research related to both execution of participatory methods, competence building, systems design, and HIS strengthening. Moreover, this thesis contributes by further developing the conceptual language around these spaces, which is useful to future research beyond the HISP project.

Related to the practical contribution of this thesis, working with a real-life problem affecting human subjects as Action Research implies, involves certain ethical responsibilities related to ensuring that the participant's contributions to the process provide something in return. One of the participating health workers commented that they have prior experiences with researchers visiting and evaluating new systems, but that they rarely see any improvement after they leave. As seen in the results, participants were very eager to see the prototype implemented as they thought it would improve their workday. For example, during a prototype evaluation, one warehouse worker commented; *"when will this be implemented so we can use it? I ask because you are now getting us all excited and we want the system now"*. However, in projects that are limited in time and reliant on a variety of external actors with diverse motives, it is hard to ensure actual implementation. Even though the research of this thesis has come to an end, the contributions of all participants will hopefully reach implementation as new master projects follow up on the results. With this, we move to the concluding chapter of this thesis, to summarize the research and its findings and provide some reflections upon topics for future research.

Chapter 7 - Conclusion

Based on a two-year Action Research project, this thesis has discussed technical and organizational factors that enable or constrain user participation during the design of data entry interfaces in a generic software package implemented as a health commodity ordering system in Uganda. User participation in data entry interface design is relevant as it is argued that the layout of such interfaces should suit the established knowledge and routines of the health workers that use them. When failing to provide sufficient clarity, data quality, timeliness, and work satisfaction might suffer. Generic software packages are relevant as they are increasingly important components of health information systems (HIS) in developing countries. However, their generic nature poses a challenge to the development of interfaces that are sensitive to local particularities. In the empirical case of this thesis, we follow a project in Uganda, which has implemented a working health commodity ordering system using the generic software package DHIS2. This has enabled improved flow of information to relevant decision-makers, but lack of clarity in the generic data entry interface used by health workers introduced issues affecting work satisfaction and data quality. As an attempt to address these problems, a new data entry interface was designed through a participatory approach by engaging health workers in the process.

The contribution of this thesis is twofold: practically, the prototype produced during the project can further help strengthening the commodity ordering system used throughout the public health system in Uganda. Moreover, learnings from the participatory process analyzed in light of existing literature form the theoretical contribution. These have been outlined and discussed as concrete enabling and constraining factors, and indications of how participation in data entry interface design can be relevant to health information systems strengthening. A summary of these are provided in the following two sections before some reflections on future research are presented.

7.1 Enabling and Constraining Factors

In line with existing literature outlining requirements for user participation (Clement & Van den Besselaar, 1993; Kensing, 1983), in generic software packages (Bansler & Havn, 1994; Fischer, 2008), developed globally (Roland et al., 2017), in a developing country context (Puri et al., 2004), the findings of this thesis indicate that 'space' for participation is shaped by several technical and organizational factors. Further, it provides rich insight on how mechanisms suggested by this prior research are at play in a local implementation project, by outlining factors that enable and constrain local customization and engaging users in the process. Through thematic analysis of the results, three technical and five organizational factors that enable and constrain this space have been identified. These are presented in Table 7-1 (also presented in chapter 6.2).

Table 7-1 Enabling and constraining factors for user participation

	Technical factors	
1	Customization capabilities	The software provides flexibility to support customization.
2	Dependencies	Capabilities for customization provide flexibility to support local customization although it is shared as a common software instance with other health programs.
3	Ease of mastery	Capabilities for customization are easy to learn and utilize.
	Organizational factors	
1	Project autonomy	The implementation initiative is provided with autonomy from other national implementation projects and the global development of the software.
2	Motivation	Involved actors are motivated to engage users in the design process.
3	Time and financial resources	Project has time and financial resources available to engage users in design.
4	Competence	There is competence on 1) methods and techniques for user involvement, and 2) utilizing available technical flexibility.
5	Participation culture	The organizational and political-cultural context enable health workers and other facility personnel to participate in decisions.

Customization capabilities in DHIS2 provided ways of customization with various levels of flexibility to respond to learnings from user participation. The capabilities' *dependency* to the software core and their *ease of mastery* partly determines the actual use of such capabilities. Organizationally, the level of *project autonomy* of the implementation project from global and national development and maintenance formed the degree of flexibility and constrained available customization capabilities. Further, the *motivation* for user involvement in design, largely determined by the aim of the project and awareness of possible benefits had an enabling and constraining effect in the two phases of the case. With lack of awareness of benefits or an aim of making generic functionality, motivation and the relevance of including users in design might be limited. As user involvement implies a process requiring more time and resources, sufficient *time and financial resources* need to be available. If the project is motivated to engage users and resources are available, *competence* on methods and techniques for user involvement need to be present. Further, competence on how to utilize the technical flexibility through the customization capabilities are needed. The level of competence required here is also related to the ease of mastery of the capabilities available. Finally, the organizational and political culture where the project is operating needs to provide a *participatory culture*, that enables user participants to take part in decisions.

Together, the technical flexibility and the organizational capability for utilization shape the space for user participation. An illustration is provided in Figure 7-1 (also presented in chapter 6.2).

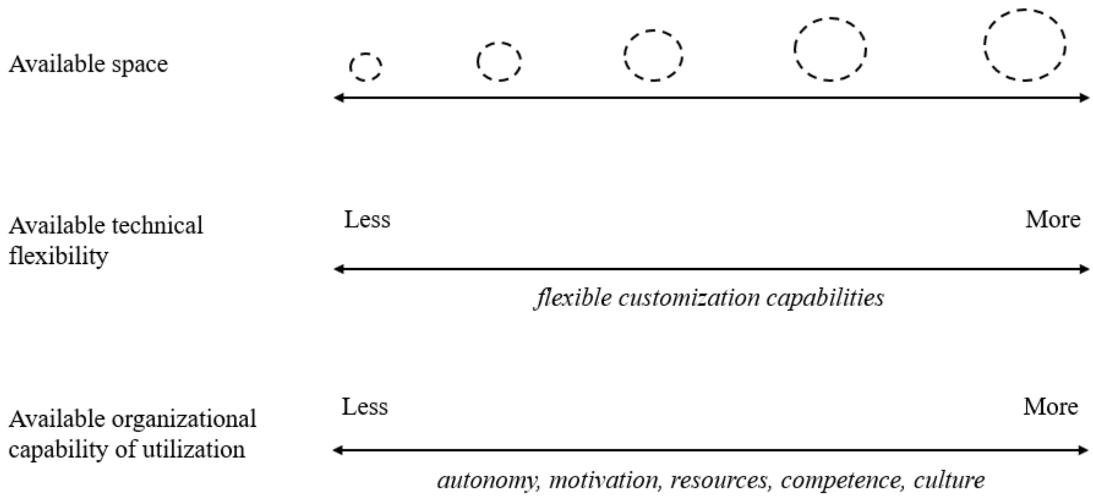


Figure 7-1 Factors that enable and constrain the space for user participation

7.2 Positive Outcomes

The findings of this thesis supports claims of existing research on HIS data collection tools (Lippeveld et al., 2000) and user participation in information systems design (Bjerknes & Bratteteig, 1995; Kujala, 2003), that iterative design processes including users, experts and developers, can increase fit between existing routines and digital design, thus providing increased clarity in data entry interface layouts. Based on experiences throughout the research process, and qualitative evaluations of the prototype developed, four possible positive outcomes have been outlined and discussed. Existing literature suggests that user participation leads to increased knowledge of use, making the design more informed, thus increasing fit between technology and established practices. In line with this, engaging users in phase two of this project proved fruitful to build a data entry interface with more clarity for health workers. Further, feedback from participants indicated that the new interface might increase work satisfaction among the users. Moreover, in line with the Participatory Design tradition, empowerment of health workers to participate in forming the technology they use can also be seen as being of intrinsic value, and user participation might promote this. Further, it was reported that data quality suffered due to unclarities in the existing interface. Removing these unclarities might eliminate such issues and in turn, improve data quality. Finally, the attractiveness of adopting the WAOS for the other reporting regimes seemed to be strengthened with the new interface, possibly resulting in integration between other health programs.

In sum, the strengthened understanding of the factors that are enabling and constraining user participation in local implementation projects, and the possible benefits of involving end-users in the design of data entry interfaces presented in this thesis might help to promote an extended focus on this topic in HIS strengthening initiatives. Ultimately, improving simplicity and clarity in computer-based data entry interfaces through user participation in design might contribute to better data quality and increased work satisfaction, and eventually, the overall goal of strengthened healthcare.

In the following section, possible topics for future research based on these findings will be discussed.

7.3 Future Research

The findings of this thesis provide the basis for several interesting topics for future research. Firstly, it would be of interest to follow the initiative in Uganda further to see whether the indications of positive outcomes are supported by evaluations of user satisfaction after real use, whether other health programs adopt the same solution, and if data quality and timeliness do increase through quantitative measures. This is already being taken on by two master students at the University of Oslo.

Further, other implementation projects could be investigated to compare and possibly gain richer insight into the factors discovered here, or other factors that influence the space for participation. This may not be limited to interfaces for data entry, as similar factors might apply in other cases, for example regarding data visualization, data approval interfaces and so forth. Moreover, as several of the factors and possible positive outcomes outlined in this thesis are trying to capture quite broad aspects, each factor may be suited for a research topic of its own. Following are some concrete suggestions for topics of future research based on the factors and outcomes discussed in this thesis.

Time and Financial Resources

Limited time and financial resources were identified as one constraining factor of participation. Thus, extended knowledge of how these factors affect similar projects could be of interest. The notion of 'frugal innovation' where technical solutions are developed to work in resource-constrained settings has been subject to increased focus in recent years. Thus, guidelines or insight into 'frugal PD', that is, how participatory methods can be adapted for resource-constrained settings might be of relevance to many implementation initiatives in the global south.

Participatory Culture

As seen, there exists a body of research on the contextuality of participatory methods. However, one can argue that as health workers with limited experience with ICTs are introduced to digital interfaces, user participation in design are increasingly relevant in new geographical areas and cultural contexts. Thus, more empirical research is needed on how methods and techniques can be carried out in these settings. Moreover, as participatory design traditionally has had an active political agenda of empowerment, this focus might be emphasized further as a measure to empower health workers as active participants in forming the technology that increasingly takes part of their everyday work.

Motivation and Competence

Motivation and competence to utilize technical flexibility and conduct methods for user participation were in this research found to be of significant relevance. Further investigation of how such competence can be strengthened in local implementation nodes, thus institutionalizing local participatory scaffolding for user interface design can be of significant relevance to practice. Here, methods of 'frugal PD' could be useful to provide implementers with guidelines for effective user involvement in resource-constrained settings. Moreover, as discussed, the participatory project of this thesis was concerned with improving aspects of a specific initiative, what Gärtner and Wagner (1996) term 'Arena A'. Moving forward, an interesting aspect for investigation is how to carry out similar processes that emphasize change in other arenas such as B: *'Stable patterns of functioning related to participation questioned and redesigned'*, and C: '*General legal and political framework is negotiated, which defines the relations between the various industrial partners and sets norms for a full range of work-related issues'* (Gärtner & Wagner, 1996, p. 195).

Customization Capabilities and 'meta-design'

As discussed, customization capabilities provide the very basis for customization and user participation in generic software. From this case, we can see that there are substantial benefits associated with using built-in tools for customization as they provided ease of mastery and therefore required less competence and time for development and prototyping. A practical, but useful topic for further research could be to investigate how built-in tools such as 'custom form' can be designed to provide more flexibility, while simultaneously maintain a reasonable level of ease of mastery. This might further be related to the development of context-appropriate and 'frugal' methods of participation.

Investigating possible Benefits

To promote user participation in the design of data entry interfaces in HIS, its possible benefits should be further explored and documented. This thesis provides indications of several positive outcomes. However, they should be explored in more detail with both qualitative and quantitative measures. For example, effects on data quality and timeliness might be measured with statistical indicators, and work satisfaction can be studied by both quantitative usability testing and long-term qualitative feedback.

Hopefully, increased interest in research on these areas might contribute to improved work conditions and health systems in Uganda and other countries in the global south.

References

AbouZahr, C., & Boerma, T. (2005). Health information systems: the foundations of public health. *Bulletin of the World Health Organization, 83*(8), 578-583.

Baldwin, C. Y., & Woodard, C. J. (2008). The architecture of platforms: A unified view.

Bansler, J. P., & Havn, E. C. (1994). *Information systems development with generic systems.* Paper presented at the ECIS.

Baskerville, R. L., & Wood-Harper, A. T. (1996). A critical perspective on action research as a method for information systems research. *Journal of information technology, 11*(3), 235-246.

Baum, F., MacDougall, C., & Smith, D. (2006). Participatory action research. *Journal of Epidemiology & Community Health, 60*(10), 854-857.

Bergum, B.-I. (2017). *Architectural Patterns in the Medical Commodity Supply Chains in Developing Countries.* (Masters thesis), University of Oslo.

Bergum, B.-I., Nielsen, P., & Sæbø, J. I. (2017). *Patchworks of Logistics Management Information Systems: Challenges or Solutions for Developing Countries?* Paper presented at the International Conference on Social Implications of Computers in Developing Countries.

Bjerknes, G., & Bratteteig, T. (1995). User participation and democracy: A discussion of Scandinavian research on system development. *Scandinavian Journal of Information Systems, 7*(1), 1.

Braa, J., Hanseth, O., Heywood, A., Mohammed, W., & Shaw, V. (2007). Developing health information systems in developing countries: the flexible standards strategy. *Mis Quarterly*, 381-402.

Braa, J., Monteiro, E., & Sahay, S. (2004). Networks of action: sustainable health information systems across developing countries. *Mis Quarterly,* 337-362.

Braa, J., & Sahay, S. (2012a). *Integrated Health Information Architecture: Power to the Users: Design, Development and Use*.

Braa, J., & Sahay, S. (2012b). Participatory Design within the HISP network. *Routledge International Handbook of Participatory Design*, 235.

Bratteteig, T., Bødker, K., Dittrich, Y., Mogensen, P. H., & Simonsen, J. (2012). Organising principles and general guidelines for Participatory Design Projects. *Routledge Handbook of Participatory Design*, 117.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative research in psychology, 3*(2), 77-101.

Central Intelligence Agency, C. (2018). Uganda. *The World Factbook.*

Chein, I., Cook, S. W., & Harding, J. (1948). The field of action research. *American Psychologist, 3*(2), 43.

Chilundo, B., & Aanestad, M. (2005). Negotiating multiple rationalities in the process of integrating the information systems of disease specific health programmes. *The Electronic Journal of Information Systems in Developing Countries, 20*.

Ciborra, C. (2000). *From control to drift: the dynamics of corporate information infastructures*: Oxford University Press on Demand.

Clement, A., & Van den Besselaar, P. (1993). A retrospective look at PD projects. *Communications of the ACM, 36*(6), 29-37.

Crang, M., & Cook, I. (2007). *Doing ethnographies*: Sage.

Damodaran, L. (1996). User involvement in the systems design process-a practical guide for users. *Behaviour & information technology, 15*(6), 363-377.

DHIS2.org. (2018). DHIS2 In Action. Retrieved from https://www.dhi2.org/inaction

DHIS2.org. (n.d.-a). Data Entry Forms. Retrieved from https://docs.dhis2.org/2.22/en/user/html/ch06s02.html

DHIS2.org. (n.d.-b). DHIS2 Academies. Retrieved from https://www.dhis2.org/academy

Dittrich, Y. (2014). Software engineering beyond the project–Sustaining software ecosystems. *Information and Software Technology, 56*(11), 1436-1456.

Fischer, G. (2008). Rethinking software design in participation cultures. *Automated Software Engineering*, *15*(3), 365-377.

Flyvbjerg, B. (2006). Five misunderstandings about case-study research. *Qualitative inquiry, 12*(2), 219-245.

Gadamer, H.-G. (1976). The historicity of understanding (pp. 117-133): Penguin Books Ltd, Harmondsworth, UK.

Gasser, L. (1986). The integration of computing and routine work. *ACM Transactions on Information Systems (TOIS), 4*(3), 205-225.

Geertz, C. (1973). *The interpretation of cultures* (Vol. 5019): Basic books.

Gärtner, J., & Wagner, I. (1996). Mapping actors and agendas: political frameworks of systems design and participation. *Hum.-Comput. Interact., 11*(3), 187-214. doi:10.1207/s15327051hci1103_1

Hagen, N. A. (2017). *Health Commodity Ordering in Uganda.* (Masters thesis), University of Oslo.

Hanseth, O., & Aanestad, M. (2003). Design as bootstrapping. On the evolution of ICT networks in health care. *Methods of information in medicine, 42*(4), 384-391.

Hanseth, O., & Lyytinen, K. (2010). Design theory for dynamic complexity in information infrastructures: the case of building internet. *Journal of information technology, 25*(1), 1-19.

Hanseth, O., Monteiro, E., & Hatling, M. (1996). Developing information infrastructure: The tension between standardization and flexibility. *Science, Technology, & Human Values, 21*(4), 407-426.

Heeks, R. (2002). Information systems and developing countries: Failure, success, and local improvisations. *The information society, 18*(2), 101-112.

Hess, J., Offenberg, S., & Pipek, V. (2008). *Community driven development as participation?: involving user communities in a software design process.* Paper presented at the Proceedings of the Tenth Anniversary Conference on Participatory Design 2008.

Hussain, S., Sanders, E. B.-N., & Steinert, M. (2012). Participatory design with marginalized people in developing countries: Challenges and opportunities experienced in a field study in Cambodia. *International Journal of Design, 6*(2).

IFS. (2017). IFS - Global Enterprise Software Solution Provider. Retrieved from http://www.ifsworld.com/us/

Kensing, F. (1983). The Trade Unions Influence on Technological Change. *Systems Design For, With and By the Users. North Holland*.

Kensing, F., & Blomberg, J. (1998). Participatory design: Issues and concerns. *Computer Supported Cooperative Work (CSCW), 7*(3-4), 167-185.

Kimaro, H. C., & Titlestad, O. H. (2008). Challenges of user participation in the design of a computer based system: The possibility of participatory customisation in low income countries. *Journal of Health Informatics in Developing Countries, 2*(1).

Klein, H. K., & Myers, M. D. (1999). A set of principles for conducting and evaluating interpretive field studies in information systems. *Mis Quarterly*, 67-93.

Kujala, S. (2003). User involvement: a review of the benefits and challenges. *Behaviour & information technology, 22*(1), 1-16.

Kyng, M. (1994). *Scandinavian design: Users in product development.* Paper presented at the Proceedings of the SIGCHI conference on Human factors in computing systems.

Li, M. (2017). *Utilizing the Space for User Participation: Experiences from a Public Health Project in Uganda*. Paper presented at the Information Systems Research Seminar in Scandinavia. http://folk.uio.no/magl/content/articles/iris17.php

Linfo.org. (2005). BSD license definition. Retrieved from http://www.linfo.org/bsdlicense.html

Lippeveld, T. (2001). *Routine health information systems: the glue of a unified health system.* Paper presented at the Keynote address at the Workshop on Issues and Innovation in Routine Health Information in Developing Countries, Potomac, March.

Lippeveld, T., Sauerborn, R., & Bodart, C. (2000). Design and implementation of health information systems. *World Health Organization*.

Ministry of Health Uganda. (2018). About Ministry of Health. Retrieved from http://health.go.ug/about-us/about-ministry-health

Mosse, E. L., & Sahay, S. (2005). The role of communication practices in the strengthening of counter networks: Case experiences from the health care sector of Mozambique. *Information Technology for Development, 11*(3), 207-225.

Nielsen, P., & Sæbø, J. I. (2016). Three strategies for functional architecting: cases from the health systems of developing countries. *Information Technology for Development, 22*(1), 134-151.

NORAD. (2015). Uganda. Retrieved from https://www.norad.no/en/front/countries/africa/uganda/

Open Health News. (2017). District Health Information System 2 (DHIS2). Retrieved from http://www.openhealthnews.com/resources/district-health-information-system-2-dhis2

OpenLMIS. (2017). OpenLMIS. Retrieved from http://openlmis.org/

Orlikowski, W. J. (2006). Material knowing: the scaffolding of human knowledgeability. *European Journal of information systems, 15*(5), 460-466.

Plantin, J.-C., Lagoze, C., Edwards, P. N., & Sandvig, C. (2016). Infrastructure studies meet platform studies in the age of Google and Facebook. *New Media & Society*, 1461444816661553.

Pollock, N., & Williams, R. (2009). Global software and its provenance: generification work in the production of organisational software packages *Configuring User-Designer Relations* (pp. 193-218): Springer.

Puri, S. K., Byrne, E., Nhampossa, J. L., & Quraishi, Z. B. (2004). *Contextuality of participation in IS design: a developing country perspective.* Paper presented at the Proceedings of the eighth conference on Participatory design: Artful integration: interweaving media, materials and practices-Volume 1.

Rapoport, R. N. (1970). Three dilemmas in action research: with special reference to the Tavistock experience. *Human relations, 23*(6), 499-513.

Rogers, Y., Sharp, H., & Preece, J. (2011). *Interaction design: beyond human-computer interaction*: John Wiley & Sons.

Roland, L. K., Sanner, T. A., Sæbø, J. I., & Monteiro, E. (2017). P for Platform: Architectures of large-scale participatory design. *Scandinavian Journal of Information Systems, 29*(2).

Rolland, K. H., & Monteiro, E. (2002). Balancing the local and the global in infrastructural information systems. *The information society, 18*(2), 87-100.

Rönkkö, K., Hellman, M., & Dittrich, Y. (2008). *PD method and socio-political context of the development organization.* Paper presented at the Proceedings of the Tenth Anniversary Conference on Participatory Design 2008.

SageUK. (2017). Sage Software and Solutions for Every Business. Retrieved from https://www.sage.com/en-gb/

SIAPS. (2014). *Considerations for the Integration of HMIS and LMIS*. Retrieved from http://siapsprogram.org/publication/altview/considerations-for-the-integration-of-hmis-and-lmis/English/

Suchman, L. (1993). Working relations of technology production and use. *Computer Supported Cooperative Work, 2*(1-2), 21-39.

SURE. (2014). *Securing Ugandans' Right to Essential Medicines Program: Final Report (2009-2014)*. Retrieved from http://apps.who.int/medicinedocs/documents/s21954en/s21954en.pdf:

Susman, G. I., & Evered, R. D. (1978). An assessment of the scientific merits of action research. *Administrative science quarterly*, 582-603.

Sæbø, J. I., Kossi, E. K., Titlestad, O. H., Tohouri, R. R., & Braa, J. (2011). Comparing strategies to integrate health information systems following a data warehouse approach in four countries. *Information Technology for Development, 17*(1), 42-60.

Sæbø, J. I., & Titlestad, O. (2004). *Evaluation of a bottom-up action research approach in a centralised setting: HISP in Cuba.* Paper presented at the System Sciences, 2004. Proceedings of the 37th Annual Hawaii International Conference on.

Titlestad, O. H., Staring, K., & Braa, J. (2009). Distributed development to enable user participation: Multilevel design in the HISP network. *Scandinavian Journal of Information Systems, 21*(1), 3.

Tiwana, A. (2013). *Platform ecosystems: aligning architecture, governance, and strategy*: Newnes.

Umlauf, R., & Park, S.-J. (2018). Stock-outs! Improvisations and processes of infrastructuring in Uganda's HIV/Aids and malaria programmes. *Global public health, 13*(3), 325-338.

UNAIDS. (2018). Uganda. Retrieved from http://www.unaids.org/en/regionscountries/countries/uganda

VillageReach. (2012). Starting At The Last Mile: Rethinking Medical Supply Chains In Low-Income Countries. . *VillageReach*.

Walsham, G. (1995). Interpretive case studies in IS research: nature and method. *European Journal of information systems, 4*(2), 74-81.

Walsham, G. (2006). Doing interpretive research. *European Journal of information systems, 15*(3), 320-330.

Walsham, G. (2012). Are we making a better world with ICTs? Reflections on a future agenda for the IS field. *Journal of information technology, 27*(2), 87-93.

WHO. (2018). Uganda. Retrieved from http://www.who.int/countries/uga/en/

Windisch, R., Waiswa, P., Neuhann, F., Scheibe, F., & de Savigny, D. (2011). Scaling up antiretroviral therapy in Uganda: using supply chain management to appraise health systems strengthening. *Globalization and health, 7*(1), 25.

Winschiers, H. (2006). *The challenges of participatory design in a intercultural context: Designing for usability in Namibia.* Paper presented at the PDC.

Appendix 1 – The Final Prototype

As a part of this thesis a prototype for a new data entry interface for commodity reporting and ordering was developed through a 'use-oriented' approach where health workers were involved throughout the design process. The aim was to address critical issues in the existing interface implemented in WAOS. Process and issues are described in Chapter 4 and 5. This appendix provide an overview of the prototype. The complete source code is available on GitHub on the following url: https://github.com/lmisuganda/entryAndApproval

Interface Overview

The result of the five-week design process was a prototype that addressed several of the issues with the existing entry interface. Notable functionality is a facility dashboard that presents unsubmitted, submitted, and approved forms, and a stepwise data entry screen. The data entry screen uses categories in the structure of the existing paper form, to group parts of the form into sections. This to minimize the amount of information on the screen.

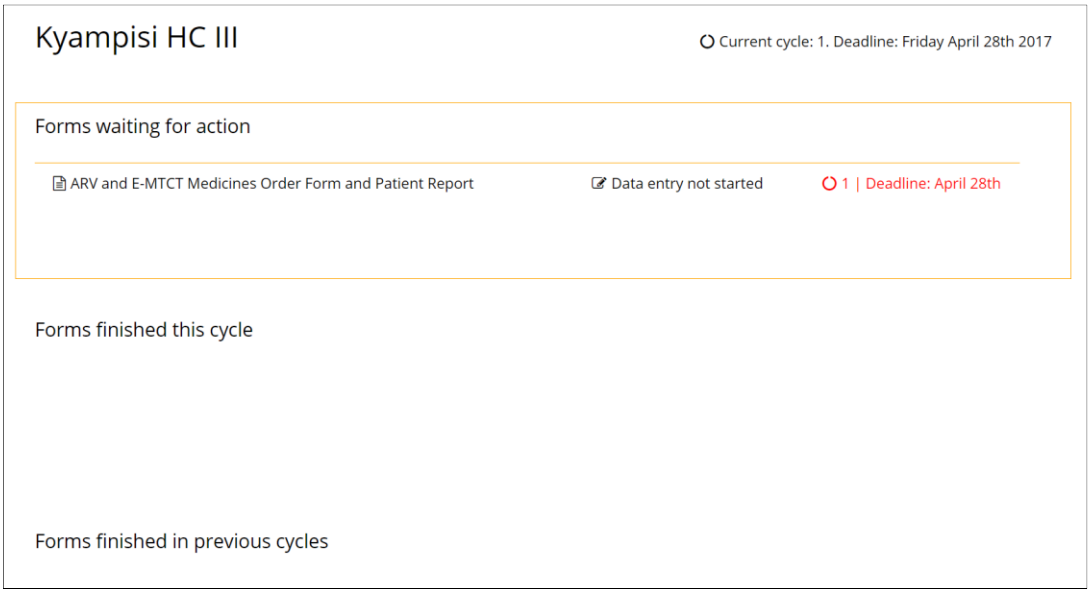
To address the same concern, the data entry tool is further divided in such way that only the information on one commodity is visible at once during entry. Several minor, but useful details were also embedded in the designed to address issues and ideas posed by entry personnel.

Following is a narrative walkthrough of the interface seen from the perspective of a data entry clerk.

The dashboard

Two of the major challenges with the existing data entry interface was confusion related to the selection of forms by cycle, and lack of immediate feedback on the completion status of forms. The facility dashboard is an attempt to address these two issues.

When data entry personnel at a clinic, hospital, district office or warehouse are ready to enter data for a cycle, they open the Commodity ordering and consumption reporting application in DHIS2. Here, they select the current facility from a list of facilities before they are presented with the facility dashboard shown in Screenshot 1.



Screenshot 1 - The facility dashboard

As it is planned to implement the same solution for other forms, such as the TB program, there might be several forms available for one cycle. The dashboard is structured with three lists.

1) Forms waiting for action displays the forms that are not completed and requires attention from the data entry clerk.

2) Forms finished this cycle provides a list of forms that have been completed in the current cycle.

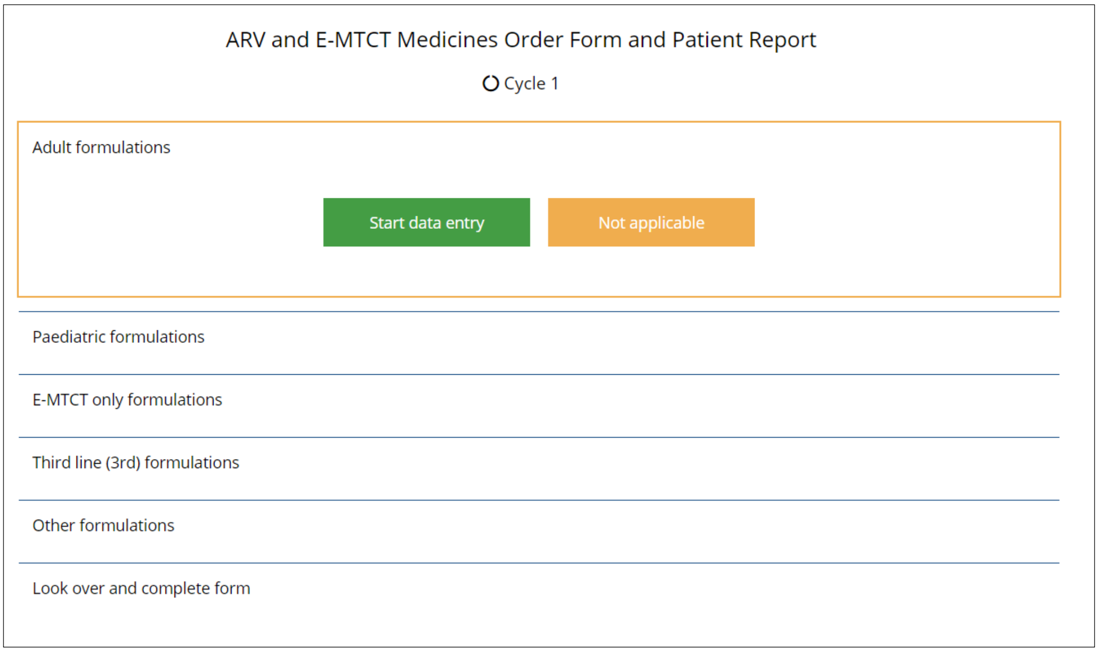
3) Forms finished in previous cycles provide a list of the forms from the last six cycles. This enables quick access to data from recent cycles for the data entry personnel.

To signalize order deadlines and current cycle, the form is marked with the cycle and deadline in the list. There is also a status element showing whether the data entry is started or if the form is completed or approved.

Form overview

The third major issue in the existing interface was the overwhelming amount of information on the screen during data entry, due to the size of the form. A stepwise data entry process attempts to address this issue.

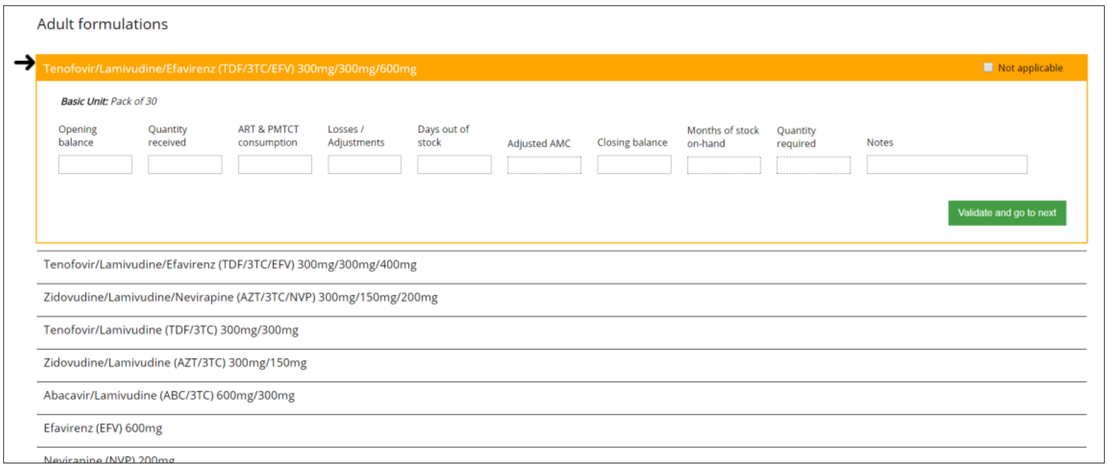
When an uncompleted form is selected from the dashboard, an overview of the form is presented (Screenshot 2). Data entry is here divided into sections, corresponding to the sections on the paper form. In the existing interface, the user had to manually enter zero-values for all commodities in a section if it was not applicable. In the new interface, a *Not Applicable* button enables the user to quickly skip these sections. To start data entry in a section, the 'start data entry' button is clicked.

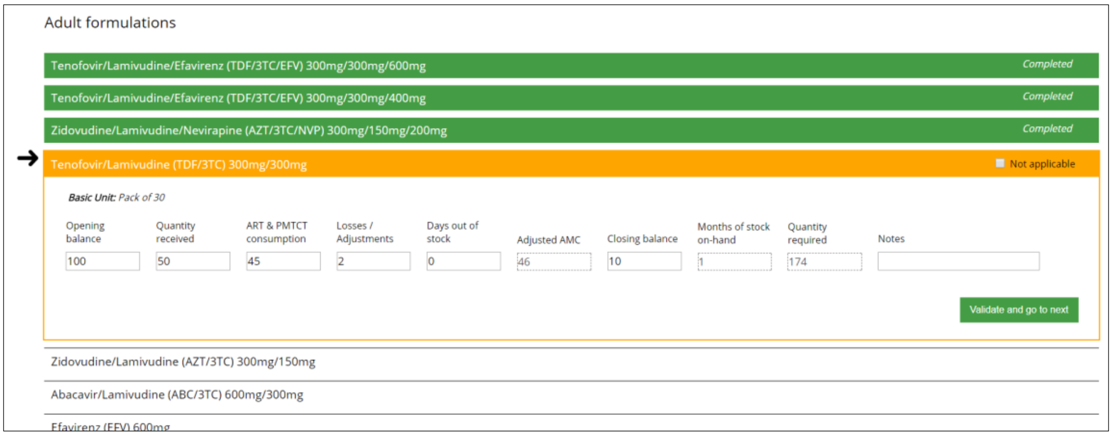


Screenshot 2 - Form overview

Data entry

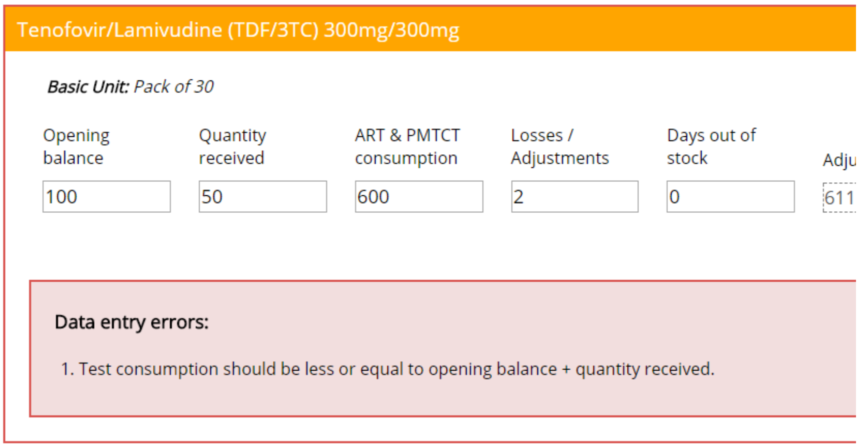
To further address the issue of information overload on the screen, the data entry screen only shows the data input fields for one formulation/commodity at the time (Screenshot 3). When all data for the current formulation is entered, the user selects "*Validate and go to next*", which opens the next formulation for data entry. Calculated data elements will be calculated automatically in the interface and instantly displayed in their respective fields.





Screenshot 3 - Stepwise data entry screen

In a further attempt to minimize misplaced or wrong values, the interface will check the values entered against a predefined list of rules. If the value is not in correspondence with this, an instruction message will be shown and the user is forced to correct this error before moving to the next formulation or commodity. In the example shown in Screenshot 4. the value of ART & PMTCT consumption is greater than the Opening Balance and Quantity Received combined, which triggers a validation message.

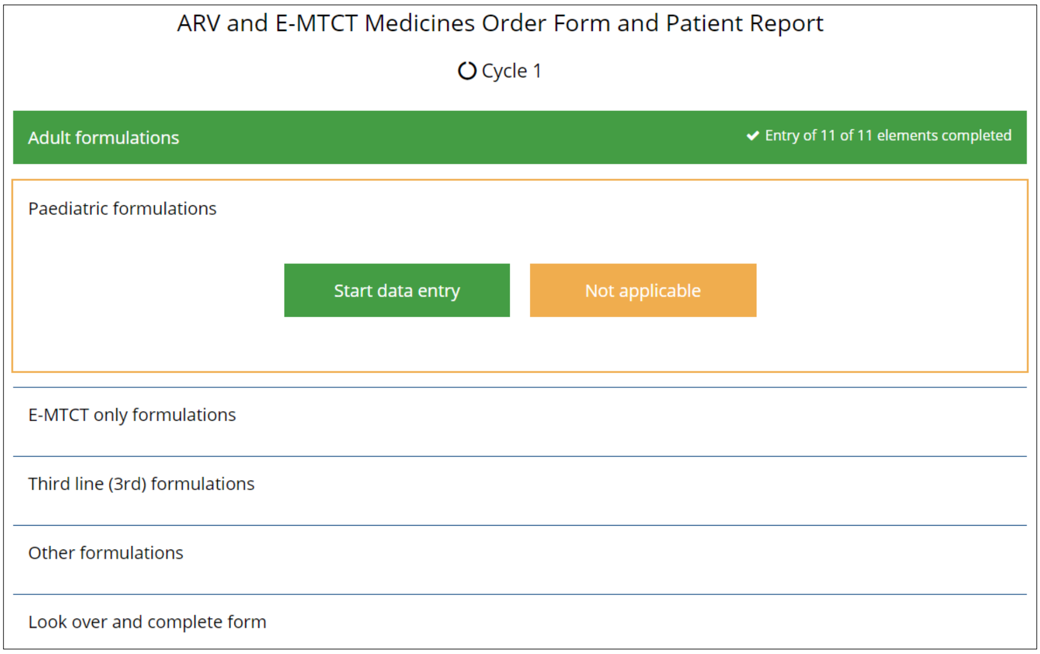


Screenshot 4 - Validation message during data entry

To ensure effective data entry for the advanced users, such as data entry personnel at the paper to computer gateways, the interface is navigable using the TAB and ENTER button.

Back to Form Overview

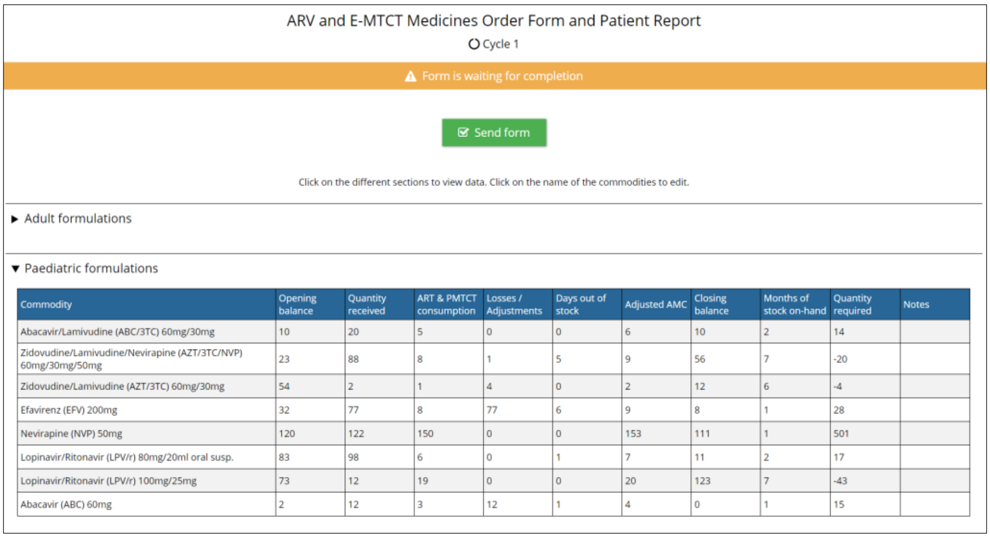
When the user has entered data and completed all formulations and commodities, he or she is again presented with the Form Overview. The section that has been completed will now be colored green, and an indicator will show that that entry of all commodities is completed (Screenshot 5). The user can now start data entry for the next section.



Screenshot 5 - Form overview: a section is colored green when completed

Form summary

During the design process, it became apparent that the stepwise data entry interface made the user uncertain about what they actually were sending in. The new design was so different from the original paper form, that it did not feel like an actual form. To make this more intuitive, the user is presented with a form summary before they press “send”. The form summary, which is illustrated in Screenshot 6**Error! Reference source not found.**, provides a final overview of the form in a tabular format. The user can look over entire sections, and click on formulations or commodities to edit values. The summary is also presented to the user when the form is opened after completion, and during approval.



ARV and E-MTCT Medicines Order Form and Patient Report

Cycle 1

Form is waiting for completion

Send form

Click on the different sections to view data. Click on the name of the commodities to edit.

▸ Adult formulations

▾ Paediatric formulations

Commodity	Opening balance	Quantity received	ART & PMTCT consumption	Losses / Adjustments	Days out of stock	Adjusted AMC	Closing balance	Months of stock on-hand	Quantity required	Notes
Abacavir/Lamivudine (ABC/3TC) 60mg/30mg	10	20	5	0	0	6	10	2	14	
Zidovudine/Lamivudine/Nevirapine (AZT/3TC/NVP) 60mg/30mg/50mg	23	88	8	1	5	9	56	7	-20	
Zidovudine/Lamivudine (AZT/3TC) 60mg/30mg	54	2	1	4	0	2	12	6	-4	
Efavirenz (EFV) 200mg	32	77	8	77	6	9	8	1	28	
Nevirapine (NVP) 50mg	120	122	150	0	0	153	111	1	501	
Lopinavir/Ritonavir (LPV/r) 80mg/20ml oral susp.	83	98	6	0	1	7	11	2	17	
Lopinavir/Ritonavir (LPV/r) 100mg/25mg	73	12	19	0	0	20	123	7	-43	
Abacavir (ABC) 60mg	2	12	3	12	1	4	0	1	15	

Screenshot 6 - Form summary: Sections can be expanded to see data in tabular format before it is sent

Technical Implementation

As described in detail in the results chapter, the existing interface of WAOS was implemented in the District Health Information Software 2 (DHIS2). The system is built with a platform architecture that comprises several layers. The platform core provides the generic data model to store data. Included is a selection of so-called bundled apps that provide basic and generic functionality to support common use-cases of data collection, analysis, and presentation. For data collection, the *standard form* tool is commonly used to support data entry in basic HTML tabular format. The *section form* functionality, provide the opportunity to split the form into sections.

For increased flexibility, the *custom form* module, provide tools to create even more customized data entry forms by allowing HTML, CSS and JavaScript code to configure the layout.

The outer layer of the DHIS2 platform architecture is enabled by a powerful Application Programming Interface (API). This allows developers to create web-based applications, that can be installed in the DHIS2 instance. The web applications, or web apps, have complete access to the underlying functionality of the platform core through the API.

A major constraining factor to the design of the existing data entry interface was the DHIS2 system's built-in form design tool. To enable full design flexibility to respond to user input, it was decided to develop the new data entry interface as a standalone web application. The application is based on HTML5, CSS3, and JavaScript. The complete source code is available on GitHub on the following url: https://github.com/lmisuganda/entryAndApproval

Offline usage

The power supply and internet connection in Uganda can be quite unstable. Especially in rural areas. During discussions and prototype evaluations this issue came up several times. If the power cuts, the machine will be turned off, and unsaved changes in the data entry interface lost. Meanwhile, the internet connection jumps in and out several times during the day. To take this into account, the prototype of the new data entry interface was implemented using HTML5 technology handling offline usage. The HTML5 Application cache is used to store the actual web application: its HTML, CSS, and JavaScript files.

The HTML5 local storage is used to store the form data. Every time a commodity is saved, the data is saved locally in the web browser Local Storage. When a section is saved, the application will try to send the updated form to the server using the API. If it fails due to lack of network, the relevant form object will be pushed to a sync queue, where it will attempt to push it to the server with a given time interval. When the connection is again available, the data will be saved to the DHIS2 server. Figure 1 illustrates how data moves from the user interface (View) through a Storage Handler function to the local storage, where it is pushed to a sync-queue to be sent to the server. Similarly, Figure 2 illustrates how information is retrieved from the DHIS2 server, saved in the local storage before presented in the view of the application.

Send data

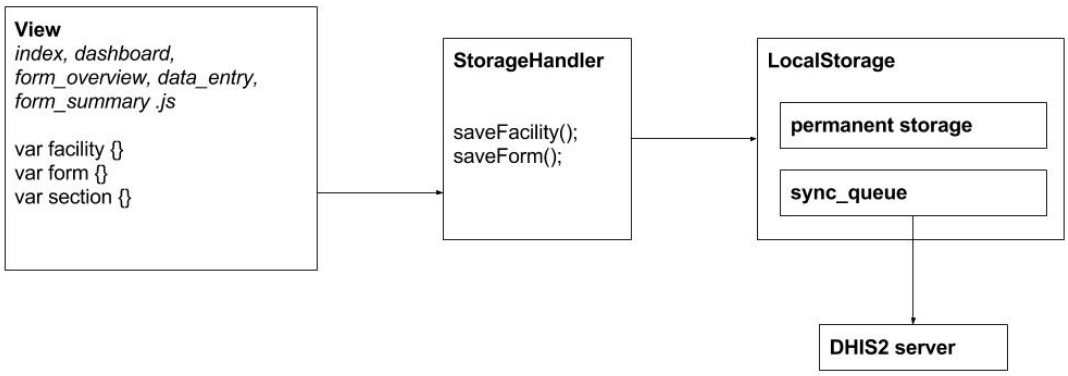


Figure 1 - Illustration of how data is handled when sending information to the server

Get data

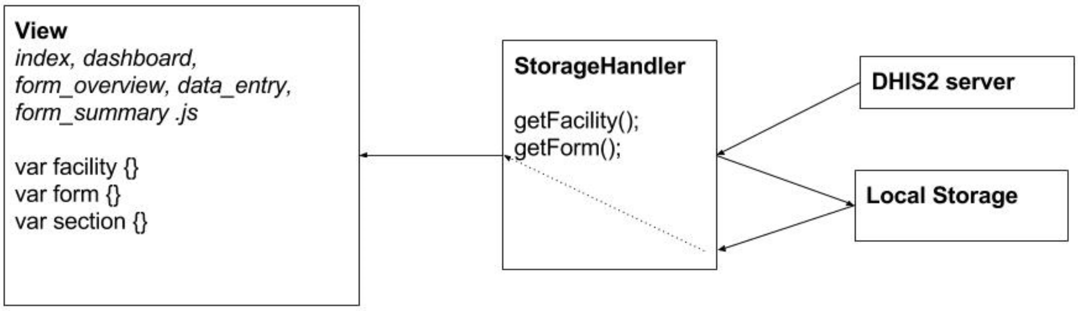


Figure 2 - Illustration of how data is retrieved from the server through the local storage

By using the offline capabilities of HTML5, the application can support offline usage, and network load is minimized. If the internet is disconnected, the user can continue working as before, and if the power cuts and the computer shut down, the data entry will resume at the previous commodity when the application is started again.

Appendix 2 – Conference Paper IRIS 2017

Utilizing the Space for User Participation: Experiences from a Public Health Project in Uganda

Magnus Li

Department of Informatics
University of Oslo

Abstract
The health information reporting regimes in developing countries are moving towards computer-based solutions. Software initially developed to support specific use cases is used in an increasing number of different domains and contexts. Strategic choices in the design of the technical and organizational architecture of these systems are made to support local flexibility in design, providing space for local end-user participation. Still, some implementation initiatives seem to suffer from a lack of utilization of this space for data entry interface design.

Based on an action research project, this paper reports from an ongoing digitization initiative on health commodity reporting in Uganda. Lack of focus on the usability for the data entry personnel caused issues related to user-dissatisfaction and reduced data quality. A new data entry interface was designed in participation with end users. Experiences on how the socio-technical architecture limited and enabled local customization and user participation in design is discussed.

Keywords: user participation, data entry interface, healthcare management, developing countries, architecture, platform, competence.

1. Introduction

Health information systems in developing countries have been subject to extensive digitization in recent decades. A main challenge has been to integrate an overall fragmented field of reporting regimes, easing the reporting burden on the workers at the lower level of the hierarchy [1]. Increasing data quality and ensuring use of data in strategic and operational decision-making is a main concern in this process. Extensive user and actor participation have been utilized when defining common standards in minimal indicator sets. Combined with data warehouse architectures, several initiatives in developing countries have proved successful in addressing these issues [2].

The rapid development of mobile internet coverage has enabled computer-based data collection at lower levels of the hierarchy, such as health clinics [3, 4]. The IT artifacts being introduced becomes important supporting components of everyday work. This is also the source of most information to be used throughout the information system. Entry errors might result in fatal consequences. Hence, the usability of the digital data entry user interfaces (UIs) of these systems can be of importance to both work satisfaction for the entry personnel, and the data quality throughout the system.

Simultaneously, information systems provided by leading initiatives, such as the Health Information System Programme (HISP), have scaled from domain and country-specific software to generic ecosystems used in a variety of use-cases in many countries. The importance of designing user interfaces adapted to domain, use, and local work practice is well discussed in the HCI literature. How are these generic interfaces adapted to local use and context? And what is required from technology and organizations to achieve end-user participation, ensuring usability for the personnel at the point of data entry?

This paper aims to share some experiences from an ongoing project in the public health commodity supply chain in Uganda, where a paper-based system has been digitized. A standard UI developed for aggregate data reporting in the open source platform DHIS2 is used for data entry. After implementation, end-users experienced issues related to fitting the UI to the work practices of the new context. As a response, a new data entry application was developed. Utilizing the space for user-participation and locally customized design, provided by the technical and organizational architecture of the project, several of the issues in the initial design was addressed.

The rest of this paper is organized in the following matter: First, background information on the global HISP project and relevant literature on user participation in large-scale systems is introduced. Then, research methods used, and the case is presented. Finally, experiences on how the socio-technical architecture enabled and limited local customization and user participation in design is discussed.

2. Background and Literature

As background and a theoretical foundation, this chapter will give a brief introduction to the Health Information System Programme (HISP). Then, key elements of user participation in information systems design, and technical and social measures to enable flexibility to design customized user interfaces in larger generic systems is presented. Finally, a description of how these challenges has been addressed in the technical and social architecture of the HISP project and the DHIS2 software is provided.

2.1 The HISP Project and DHIS2

Developing countries in Africa and Asia, often labeled the global south, has made important steps towards more unified and integrated health management information systems (HMIS) the last decades. Traditionally, the field of HMIS in developing countries have suffered from fragmented reporting systems with low-quality data to limited use for decision-making throughout the health system [1, 5]. Successfully addressing these issues with various socio-technical measures, the Health Information Systems program (HISP), have grown from a local health management information system (HMIS) initiative in South Africa to a global project, present in several countries in the global south [1, 2].

The District health information software (DHIS), sprung out of the South African HMIS initiative in the 90s. As the HISP project expanded to new countries, it has expanded from a limited use case of supporting decease case reporting, to an extensive generic platform used for data collection, organizing, and presentation of data in several domains [1]. Examples are disease surveillance, patient follow-up, and health logistics. It is often used as a data warehouse, where information is stored and presented to actors in various ways, based on their information needs.

A factor of success, and the overall goal of the HISP project has been to bridge the divide between developers and users. Methods and techniques from the Scandinavian tradition of Participatory Design have been utilized in this process [6, 7].

2.2 User Participation in Design of Information Systems

User participation has increasingly been recognized as an important part of information systems design the last decades [8]. To capture accurate user requirements, and ensure fit between technology, its user interfaces, and use and work setting, end users are engaged as experts to work together with system developers [9, 10]. The tradition of

Participatory Design (PD) grew out of Scandinavian initiatives in the late seventies and eighties. As new computers were introduced in the workplace, researchers and workers argued that these systems mainly provided management innovative ways to exercise control, and that too little emphasis was made on improving working conditions [8]. Therefore, important goals in the PD tradition have been to build better-suited systems for work settings, increase work satisfaction and acceptance for new technology, and to strengthen workplace democracy by providing workers the opportunity to participate in important technological decisions affecting their work [8, 11].

Participatory Design emphasizes the involvement of users throughout the whole development process. It is a mutual learning process where users and developers learn about the organization, work context, and technological possibilities [11]. The developers should continuously build on their own understanding of the organization and their work situation. The knowledge is used to build scenarios and prototypes to present and discuss with end users, to generate ideas and discover further issues and challenges [12].

2.3 Technical and Social Architecture to Support Local Variety

As information systems get increasingly global and interconnected, the variance in use cases and work settings provides challenges in ensuring systems' designs are well suited for specific work situations [13]. The systems are made generic to support the different use and work settings. To minimize the gap between generic functionality, UIs, and the different work routines and contexts, the technical and social architecture of these information systems needs to provide space for shaping and modification of systems and user interfaces. Fischer [10] use the term *meta-design* when designing such socio-technical architectures. These flexible spaces for customization and innovation are required to enable user participation in such large and generic systems [6]. This relies on both technical, social and organizational factors, termed technical and social architectures by Fischer [10].

Platform theory addresses critical issues related to the balance between global generic functionality and local requirements in information systems. The technical architecture of a platform consists of a generic core and functionality enabling development of more customized modules, often called apps [14]. These apps can be developed to provide additional functionality and more customized structure and design. Together, the platform core, its modules, and the surrounding social architecture form a socio-technical ecosystem, capable of adapting to changes in use and environment, suitable for complex systems where requirements are heterogeneous, and that are required to adapt to future changes [15].

With an increasing physical and organizational distribution of developers, designers, and users, the organizational structuring of socio-technical ecosystems is important to enable local customization [16]. Various measures, such as knowledge sharing mechanisms, distributed development, and design competence are crucial to make use of the flexibility provided by the technical architecture [10].

2.4 Flexibility for Local Requirements in the HISP Project

As the HISP project has scaled to support a variety of contexts, domains, and use-cases, the software, and the HISP organization have adopted several mechanisms to enable flexibility for local customization [6, 16]. The DHIS software (now named DHIS2), has emerged as a platform architecture. The platform provides bundled applications which are designed to support a variety of use cases. This includes modules for data collection and presentation, that offers flexibility for customization to enable local modifications without the need of programming [17].

Further, the platform offers easily accessible APIs, enabling development of web-based applications that communicate with the underlying architecture.

Three main options for designing customized data entry user interfaces are available in the DHIS2 software. *Standard and section forms* and *Custom forms* are built-in modules or *Bundled apps* in the software that enables basic customization of the entry forms by using settings in the software [18]. In addition, Custom Forms provides the opportunity further customize the entry forms using basic programming. To achieve full flexibility, stand-alone web apps can be developed, using the DHIS2 API. The apps can be imported into the DHIS2 software, so it is easily accessible along with existing functionality. Table 2-1 summarizes the flexibility provided by these three different options for data entry design in the DHIS2 software.

Table 2-1. Options available for data entry interface design in DHIS2, and the flexibility it provides.

Flexibility for custom interface design	Low ←→ High		
Solution in DHIS2 platform	Standard and section form	Custom form	Web app
Platform layer	Bundled apps		Custom app using API
Customization possible	Basic configuration of placement and labels on input fields, and sections of form.	Design of form with basic web programming	Full flexibility for web programming, not only limited to the form itself.

As important as the technical flexibility, is the availability of local competence for implementation and development. The HISP project has focused on local capacity building in implementing countries, resulting in a distributed network of developers and implementers. These local implementers are able to communicate with, and engage users and actors in their respective contexts, and to further communicate innovations, learnings and best practices to the core developers in charge of maintaining the generic core of the platform, situated in Oslo, Norway [6]. Provided with flexible tools such as custom forms and web apps using the API, local developers can fit the technology to local requirements.

The network of knowledge is continuously expanded through the DHIS2 academies, which are held in various countries in the global south several times a year. The academies function as arenas for building local competence and sharing experiences between implementers, developers, and other actors [16].

After a brief presentation of the research methods used, we turn to the case of implementing a commodity ordering system in Uganda, based on the DHIS2 platform through the HISP network.

3. Research Methods

The empirical learnings presented in the following chapters are based on the research project of two master students. It includes an interpretive case study of the health commodity supply chain of Uganda, and learnings from an action research project that followed the case study.

3.1 Case Study

An interpretive case study [19] was conducted during a four-week field trip to Uganda in January 2016, and partly on a five-week visit in August and September same year. The goal was to visit various types of facilities, district offices, and warehouses to get an overview of the various information systems in use for consumption reporting, ordering, and inventory management.

For each facility, warehouse and district office, the study consisted of document analysis of available literature, discussions with representatives from the Ministry of Health, formal and informal interviews and observations. Some of the facilities and one warehouse were visited multiple times to further discuss previous findings. Several meetings with representatives from the Ministry of Health (MOH) and the implementers and developers at the local HISP node in Uganda were also conducted.

Data analyses were performed by jointly writing up summaries for each facility while discussing the information collected. This information was also compared to various reports and strategy documents provided by the Ministry of Health. Emphasis was put on understanding the commodity information flow inside the facility and to the district and warehouse level. Figures mapping out the information flow between humans, information systems, and locations were drawn for each facility, district office, and warehouse. The findings were used to form new interview questions at later visits. These were later compared to identify patterns and deviations.

3.2 Action Research Project

Findings in the initial case study and discussions with the MOH triggered an action research project, where a data entry application for facility workers was designed and developed through several iterations with extensive end-user participation. The five stage model of Susman and Evered [20] was used as a foundation to structure the process, containing a diagnosis of the problem, action planning, action taking, evaluation, and specifying project learnings. The participating researcher (the author of this paper), had a significant role in the project, functioning as a developer and designer. Working closely with representatives from the local HISP implementer team, MOH and the end-users engaged to identify issues, ideas, and solutions for the interface design.

The participatory design process involved several iterations of prototyping and evaluation. Intra-project relevant design-specific learnings, as well as overall research learnings related to the project, were documented, analyzed and discussed as the project unfolded. Findings relevant to the research were discussed with fellow researchers at the University of Oslo continuously. Table 3-1 provides a summary of the action research process.

Table 3-1. Summary of action-research process

Stage	Diagnosis	Planning	Action	Evaluation	Specifying learning
Description	Experiences from case study, further observation, discussions with end-users and experts	A plan for interventions was developed with developers and MOH. Facilities were contacted to recruit participants for design	Several iterations of prototyping with end-users. Focus groups, discussions at facilities and prototype testing with end-users.	Discussions of the process and high-fidelity prototype with MOH, developers, and end-users.	Discussions with fellow researchers. Project report and research article written.

Further details from the design process of the action research project is presented in the case description.

4. Case

The following presented case describes a digitization process of a paper-based commodity ordering and consumption reporting information system. The process consisted of an overall architectural design process, and two phases of data entry interface design: 1) The first data entry interface, based on the built-in component *Custom forms* in DHIS2, and 2) the design of a new data entry interface in a web application, to address issues in the first version. The two processes are characterized by the choice of the technical component in use for interface customization and different approaches to end-user involvement in the design.

4.1 The Project and its Overall Architecture

The overall Health Management Information system (HMIS) in Uganda is divided into several decease-specific programs. Health commodity ordering and consumption reporting are divided into eight independent reporting regimes, which uses different paper forms. The forms are filled out by facilities bimonthly, with six so-called *cycles* per year. It is then sent to the district office for approval, before being forwarded to the appropriate warehouse (see Figure 4-1).

The Ministry of Health in Uganda (MOH) has been using DHIS2 as a national data warehouse for data reporting in various health programs for several years. In 2012, the HIV-pharmacy division of MOH decided to replace their paper-based ordering and consumption reporting system for HIV-related medicines with a digital system. Since DHIS2 already was used in other health-related domains and had proven successful, it was decided to use the national data warehouse and DHIS2 to support ordering and consumption reporting for these medicines. The local HISP node in Uganda was engaged as implementers and developers of the solution.

Figure 4-1: Old paper order and report regime (still in use by the other health programs)

Most health facilities in Uganda, especially outside of Kampala, lack access to computers. To handle orders from these facilities, paper-to-computer gateways were set up at the relevant district health offices. When a paper form is received from a facility, it is manually entered into DHIS2 by dedicated entry personnel. If the facility also lacks computers, the paper form is forwarded to the assigned warehouse, where it is entered digitally. Hence, dedicated entry personnel at both district and warehouse level use the data entry form in DHIS2 daily. The accuracy of their work is highly important since the dispensing of medicines relies on correct data in the orders. The data is also used for statistical purposes by the Ministry of Health, highly reliant on accurate data to identify trends and predict future commodity needs.

If a possible error is identified in a form received from a facility, the district pharmacist or warehouse officer will contact the facility by phone to clear up whether the value entered is correct.

The flow of reports in the new digital HIV-commodity reporting regime is shown in Figure 4-2. When reports are entered into the DHIS2 data warehouse, it is accessible for use by the various actors throughout the supply chain.

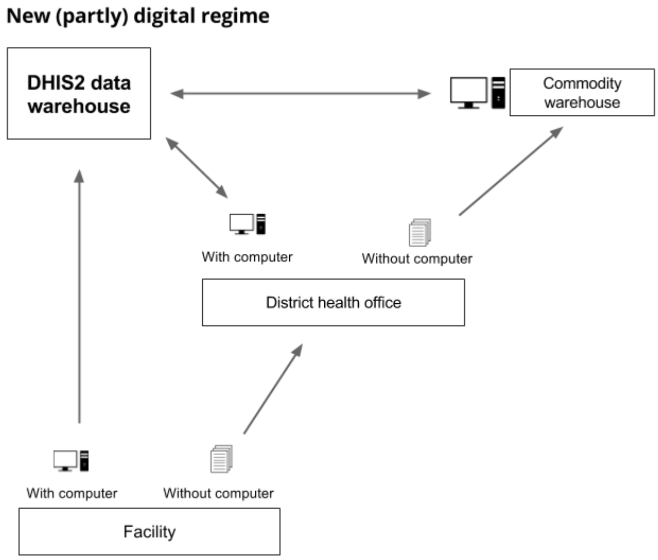


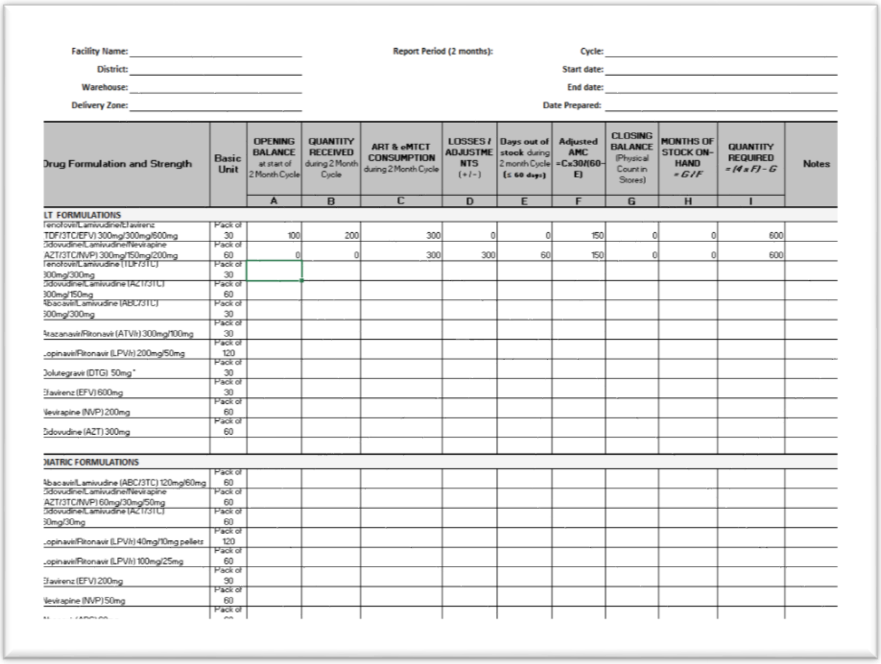
Figure 4-2. Flow of orders and reports in the new system. Facilities and district offices without computers send paper forms to the above level, where it is entered into DHIS2.

4.2 Design Phase One: The First Digital Form

With entry personnel at the facility, district, and warehouse level, the digital user interface for data entry is frequently used by a range of users with different levels of skill regarding the use of desktop computers.

The paper form to replace consisted of rows and columns for consumption reporting on various commodities, including elements such as opening balance, monthly consumption, losses and adjustments, days out of stock, and five more data input fields for other essential information. In total, the form which is presented in Figure 4-3, contains rows for 32 commodities. Each commodity requires nine or ten elements, presented as columns.

In addition, 24 rows of patient statistics are required. Each with two columns for existing and new patients on a specific regimen. This information is used for aggregate information, and during approval of the form at higher levels of the supply chain.



Facility Name: ________ Report Period (2 months): Cycle: ________
District: ________ Start date: ________
Warehouse: ________ End date: ________
Delivery Zone: ________ Date Prepared: ________

Drug Formulation and Strength	Basic Unit	OPENING BALANCE at start of 2 Month Cycle	QUANTITY RECEIVED during 2 Month Cycle	ART & eMTCT CONSUMPTION during 2 Month Cycle	LOSSES / ADJUSTMENTS (+/-)	Days out of stock during 2 month Cycle (≤ 60 days)	Adjusted AMC =Cx30/(60-E)	CLOSING BALANCE (Physical Count in Stores)	MONTHS OF STOCK ON-HAND = G/F	QUANTITY REQUIRED = (4 x F) - G	Notes
		A	B	C	D	E	F	G	H	I	
LT FORMULATIONS											
Tenofovir/Lamivudine/Efavirenz (TDF/3TC/EFV) 300mg/300mg/600mg	Pack of 30	100	200	300	0	0	150	0	0	600	
Zidovudine/Lamivudine/Nevirapine (AZT/3TC/NVP) 300mg/150mg/200mg	Pack of 60	0	0	300	300	60	150	0	0	600	
Tenofovir/Lamivudine (TDF/3TC) 300mg/300mg	Pack of 30										
Zidovudine/Lamivudine (AZT/3TC) 300mg/150mg	Pack of 60										
Abacavir/Lamivudine (ABC/3TC) 600mg/300mg	Pack of 30										
Atazanavir/Ritonavir (ATV/r) 300mg/100mg	Pack of 30										
Lopinavir/Ritonavir (LPV/r) 200mg/50mg	Pack of 120										
Dolutegravir (DTG) 50mg*	Pack of 30										
Efavirenz (EFV) 600mg	Pack of 30										
Nevirapine (NVP) 200mg	Pack of 60										
Zidovudine (AZT) 300mg	Pack of 60										
DIATRIC FORMULATIONS											
Abacavir/Lamivudine (ABC/3TC) 120mg/60mg	Pack of 60										
Zidovudine/Lamivudine/Nevirapine (AZT/3TC/NVP) 60mg/30mg/50mg	Pack of 60										
Zidovudine/Lamivudine (AZT/3TC) 60mg/30mg	Pack of 60										
Lopinavir/Ritonavir (LPV/r) 40mg/10mg pellets	Pack of 120										
Lopinavir/Ritonavir (LPV/r) 100mg/25mg	Pack of 60										
Efavirenz (EFV) 200mg	Pack of 90										
Nevirapine (NVP) 50mg	Pack of 60										

Figure 4-3. Page one (of three) of the paper form, used as a basis for the digital design

The form was designed digitally by using the layout of the paper form. The standard *Custom form* module for designing entry forms in DHIS2 was used.

This was developed and designed by one local implementer and developer, in cooperation with a representative from the global DHIS2 core developer team from Norway. The layout was tested by one logistics expert at the MOH, with extensive experience from working with digital spreadsheets in Microsoft Excel.

Experiences

The transition from the old paper system to DHIS2 has been described as quite successful. Especially by the Ministry of Health, which have been provided with easy access to consumption data from all facilities.

On the other hand, the digital user interface for the data entry personnel introduced issues that increased the burden on the facility workers. The interface provided issues on two aspects particularly; 1) finding and selecting the form for the right reporting cycle, and 2) entering data into the extensive form.

The screen for selecting forms based on facility and data are originally designed for standard aggregate reporting, and with a certain work process and domain vocabulary in mind. The organization of forms by cycles did not match the logic of dates in the interface, which created confusion. In addition, the various paper systems at clinics and hospital pharmacies often relied on the visibility of physical forms as a reminder of finished and unfinished tasks. The digital interface lacked this immediately visible indicator of form completion and now required additional work to identify submitted forms.

Entering data into the digital form itself was described as overwhelming by many of the entry clerks, making the entry process a hard and unpleasant task. The amount of input fields presented on the screen required scrolling in both horizontal and vertical direction, a complicated task for users with limited experience with desktop computers. The entry personnel described the process of data entry as one which requires time, and deep concentration, to avoid entry errors.

One frequent occurring problem was that values are entered in the wrong column. When discovered by the entry clerk, the use of a computer mouse is required to go back and change the value, while simultaneously looking at the original paper form. Often, these errors are not discovered. This was confirmed by the workers at district and warehouse level, reporting that they too often see strange or misplaced values in the digital form. If discovered, this requires the extensive task of contacting the facility by phone, to get the correct data. If not, wrong amounts of important commodities will be dispensed, possibly resulting in fatal consequences.

4.3 Design Phase Two: A New Entry Interface

After rollout, the MOH became aware of the issues related to the interface of the digital system. The two master students conducting the case study of the commodity supply chain, also noticed the concerns described by the entry personnel. During a discussion with the MOH, and the developers of the first interface, it was agreed that one of the students (the author of this paper) would work on a new entry interface, tailored to the domain and work routines of the data entry personnel.

To enable full design flexibility, it was decided to develop the data entry interface as a standalone web application for DHIS2, communicating with the platform core through the standardized API.

Standard PD techniques [8] were used to engage and communicate with user participants. Knowledge from the initial study was used as a basis, and new observations, interviews, focus groups, and discussions with data entry personnel at relevant facilities and offices were conducted. Improved knowledge of work context and routines and issues and ideas from the users involved formed the basis for initial conceptual paper prototypes.

These prototypes were again presented and discussed with end users before improvements were made. The process of prototyping, discussions, and evaluations was performed in several iterations, with increasing prototype fidelity. Figure 4-4 shows images from a focus group discussion with data entry personnel at one warehouse, and prototype evaluations at two facilities.

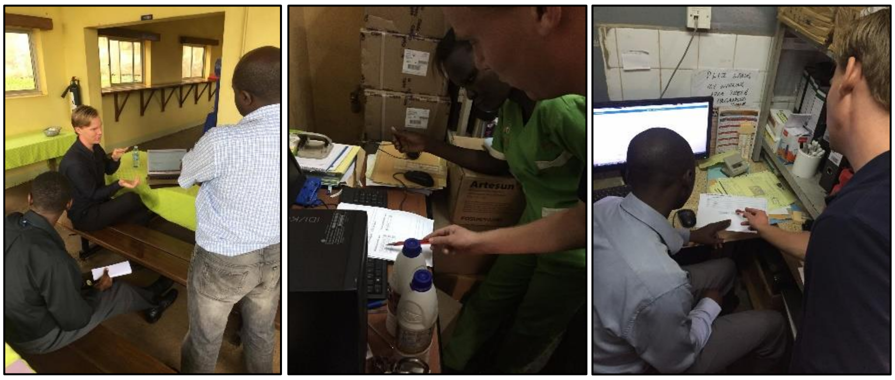


Figure 4-4. Prototype presentations and discussions

The result of the five-week design process was a prototype that addressed several of the issues with the existing entry interface. Notable functionality is a facility dashboard that presents unsubmitted, submitted, and approved forms, and a stepwise data entry screen. The data entry screen uses categories in the structure of the existing paper form, to group parts of the form into sections. This to minimize the amount of information on the screen.

To address the same concern, the data entry tool is further divided in such way that only the information on one commodity is visible at once during entry. Several minor, but useful details were also embedded in the designed to address issues and ideas posed by entry personnel. Figure 4-5 provides images of the dashboard and the stepwise data entry screen.

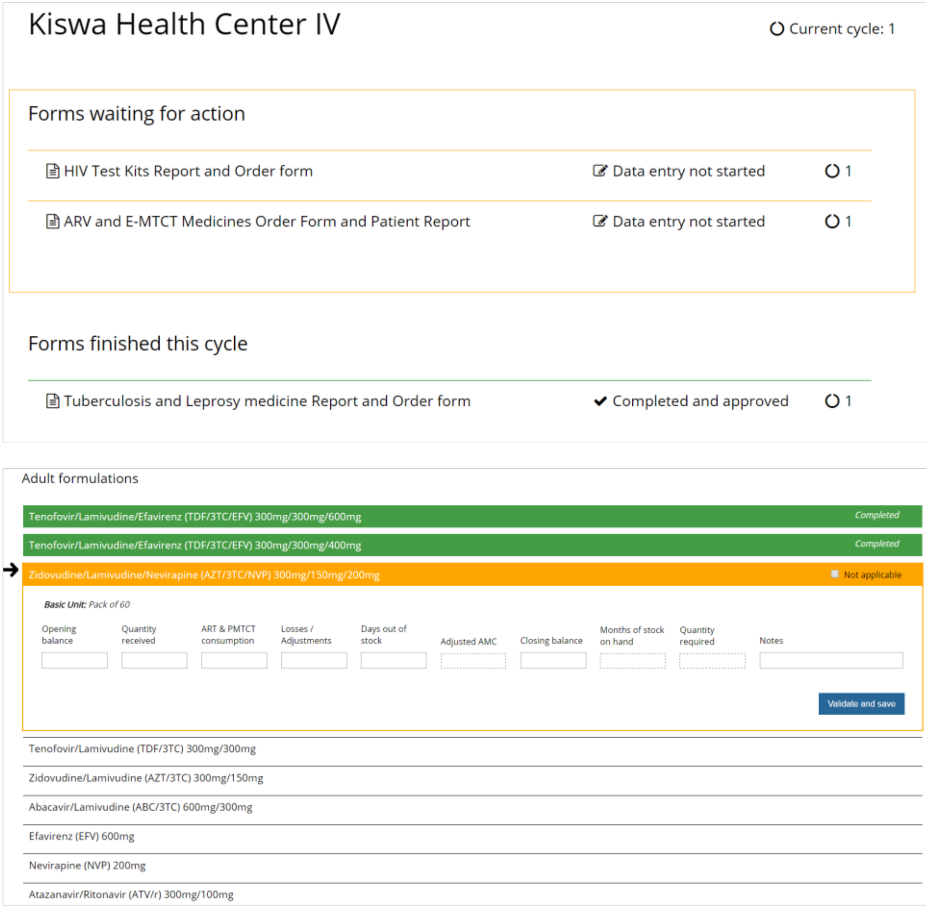


Figure 4-5: The new facility dashboard and stepwise entry interface

During presentations of the prototype to the MOH, representatives responsible for other health commodity reporting regimes expressed interest in implementing the same solution. The usability and end-user acceptance for the solution, indicated by data entry personnel, was an attractive feature of the new solution.

The interface is now being implemented in the HIV program and is scheduled for final testing and deployment in June 2017.

Table 4-1. Summary and comparison of technical solution and user participation in the development of the two interfaces.

	Phase 1: first interface	Phase 2: second interface
DHIS2 data entry interface solution	Bundled app: Custom forms	Standalone web app using the DHIS2 API
Customization	Design of a custom form, based on the paper layout.	Form split into sections, and stepwise data entry. Dashboard for forms, organized by status.
End-user participation in design	None. Only expert evaluation with one representative from MOH	Contextual interviews, and discussions, focus groups, prototype evaluation and idea-generation with end-users.

5. Discussion

Lack of emphasis on domain and context-situated design of the first data entry user interface resulted in challenges relevant to the overall goal of increased data quality and unification of fragmented reporting regimes. Several elements of the digital form design introduced errors that were reported to negatively affect data quality and timeliness of reporting. As seen in the second phase of development, the increased user acceptance that came with improved usability might play an important role in the attractiveness for adaptation by other parallel reporting regimes.

Despite working with a pre-developed software, used in many other use-cases in various countries, it was possible to customize elements of the interface to support the local context. Still, the development approaches in the two phases unfolded differently regarding end-user involvement in design. What role did the technical and social architecture play, and what can explain the different approaches in the two phases?

5.1 Enabling and Constraining Factors of the Socio-technical Architecture

The overall socio-technical architecture provided flexibility and space for customized design. This enabled customization to respond to local requirements, building on the generic platform core. The local node of HISP developers had technical competence and a close geographical and cultural proximity to the use context. It also had full autonomy from requirements and ongoing development of the core application. The DHIS2 software provided several options for custom design, through the Custom forms tool, and the web apps and API.

In the first phase, the built-in custom forms solution was used to implement the data entry form. The flexible nature of the tool enabled the developers to design a form with a layout based on the paper form already in use. The resulting size of the form, and the fundamental logic of form selection in the DHIS2 module in use, provided usability issues and a mismatch with the existing work routines. Challenges that might have been avoided with the engagement of end-users in design, and more investigation of the use and context of the existing system. However, the choice of the built-in Custom forms module would have limited the level of customization available to respond to user needs.

In the second phase, the end-users and developers designed the interface based on local needs, before the solution was connected to the underlying technology. To avoid limitations introduced by the built-in Custom Form tool in the second phase, it was decided to use the platform API to develop a web app.

This enabled the developers to meet specific issues, ideas, and concerns posed by the end-users. This included fundamental changes beyond the layout of the form itself, such as the visualization of forms on a dashboard screen.

In other words, the choice of the technical component in use for customization affected the possibilities to meet specific user requirements. Still, the component used in the first phase provided such sufficient flexibility for customization that user involvement would be relevant, however, this was not utilized.

5.2 Utilization of Available Flexibility

One explanation for the choice of technological component used, and the lack of user participation in design in the first phase, is the time and resources required to develop a more tailored design. Using standard and generic components existing in DHIS2, with a minimum degree of customization, enabled fast and efficient development and implementation. The design process of the second entry interface required considerable time, for developers, designers, and the participating users. This unfolded in a *greenhouse setting* [8], where the research project provided a protected setting with extended resources for participant access, design and user-involvement competence and software development.

Motivation and Competence

Another factor relevant to the choice of inquiry in the first design process was access to competence on benefits, challenges, and execution of user participation in interface design.

To motivate project developers and other stakeholders to invest in user involvement has proven to be challenging [12]. Initiating such initiatives required a significant level of commitment by the involved implementer and customer. In this case, the local HISP node and the MOH. Meetings and workshops with essential staff from various facilities, warehouses, and district health offices had to be planned, arranged and performed. To justify this, the involved actors must have knowledge on what benefits it might provide.

Figure 5-1 illustrates how the technical and social architecture of the project provided space for user involvement during the design of user interfaces. Local motivation and competence for and on user involvement in interface design seemed to be lacking in the first design process, which might explain the different approaches in the two design projects.

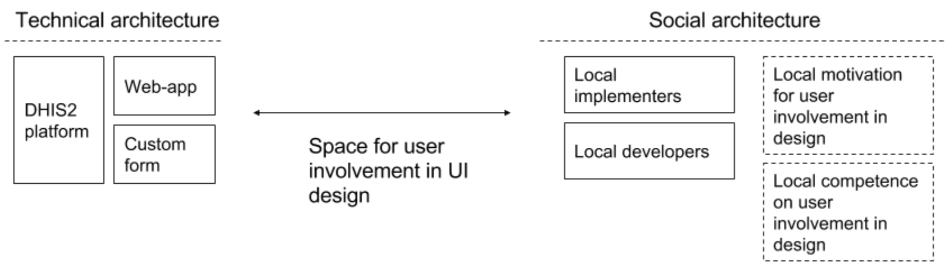


Figure 5-1. The space for user involvement provided by the socio-technical architecture in the project. The local motivation for, and competence on user involvement in design (dashed boxes) seemed to lack in the initial development of the data entry application.

Knowledge and information to motivate such a process needs to be presented to the various stakeholders by local developers and implementers, and with an amount of authority. The same competence is also necessary to perform the design process itself.

With increased flexibility, competence on development and design is required. Table 5-1 summarize how the different options for customized interfaces in DHIS2 provides various levels of flexibility and the corresponding competence in software development and design required to utilize this.

Table 5-1. Competence required when using the different technical solutions in the DHIS2 software

Design flexibility	Low ⟵⟶ High		
Technical solution	Standard and section form	Custom form	Web app
Development competence required	Basic DHIS2 implementation.	Basic HTML and CSS.	Advanced web programming skills.
Design competence required	Some visual design experience	Visual design, interaction design, user involvement, user-centered design.	

Building Competence
It has become common for educational institutions in western countries to provide courses on Human-computer interaction, user participation, and user-centered design. The goal is to enable students to acquire an appreciation for the value of user participation in design, and learn tools and techniques [8]**.** It takes time and practice for developers and computer experts to learn to listen to the users, and focus on their problems before own preferences and technological opportunities and limitations. Increased focus on this topic in local competence building could promote enhanced usability in digital data entry interfaces.

As mentioned in chapter 3, the DHIS2 academies provide an arena for knowledge sharing and learning for new implementers and developers. Topics cover data use, the configuration of more specific components, and technical implementation and customization of generic software. To stimulate increased focus on user participation in interface design, this might be an arena to introduce basic principles and techniques on this topic.

6. Conclusion

This paper has presented and discussed a case where the generic software DHIS2, has been implemented through the global HISP program. Several characteristics of the systems socio-technical architecture provided flexibility and space for data entry interface customization and user participation to meet local requirements. The space for user participation was utilized differently in the two phases of the project. A major differentiating factor was motivation for, and knowledge of benefits on end-user participation in design. Extended emphasis on this topic in local competence building might promote increased focus on enhanced usability in data entry applications. A factor that might play an important role in reaching the goals of increased data quality and unification of reporting regimes.

7. References

1. Braa, J. and S. Sahay, *Integrated Health Information Architecture: Power to the Users: Design, Development and Use*. 2012.

2. Sæbø, J.I., E.K. Kossi, O.H. Titlestad, R.R. Tohouri, and J. Braa, *Comparing strategies to integrate health information systems following a data warehouse approach in four countries.* Information Technology for Development, 2011. **17**(1): p. 42-60.

3. Manya, A., J. Braa, L.H. Øverland, O.H. Titlestad, J. Mumo, and C. Nzioka. *National roll out of District Health Information Software (DHIS 2) in Kenya, 2011–Central server and Cloud based infrastructure*. in *IST-Africa 2012 Conference Proceedings*. 2012.

4. Shaw, V. and J. Braa. *Approaches to participatory design in Africa in the age of cloud computing*. in *Proceedings of the 13th Participatory Design Conference: Short Papers, Industry Cases, Workshop Descriptions, Doctoral Consortium papers, and Keynote abstracts-Volume 2*. 2014. ACM.

5. Chilundo, B. and M. Aanestad, *Negotiating multiple rationalities in the process of integrating the information systems of disease specific health programmes.* The Electronic Journal of Information Systems in Developing Countries, 2005. **20**.

6. Titlestad, O.H., K. Staring, and J. Braa, *Distributed development to enable user participation: Multilevel design in the HISP network.* Scandinavian Journal of Information Systems, 2009. **21**(1): p. 3.

7. Braa, J. and S. Sahay, *Participatory Design within the HISP network.* Routledge International Handbook of Participatory Design, 2012: p. 235.

8. Kensing, F. and J. Blomberg, *Participatory design: Issues and concerns.* Computer Supported Cooperative Work (CSCW), 1998. **7**(3-4): p. 167-185.

9. Kujala, S., *User involvement: a review of the benefits and challenges.* Behaviour & information technology, 2003. **22**(1): p. 1-16.

10. Fischer, G., *Rethinking software design in participation cultures.* Automated Software Engineering, 2008. **15**(3): p. 365-377.

11. Bjerknes, G. and T. Bratteteig, *User participation and democracy: A discussion of Scandinavian research on system development.* Scandinavian Journal of information systems, 1995. **7**(1): p. 1.

12. Kyng, M. *Scandinavian design: Users in product development*. in *Proceedings of the SIGCHI conference on Human factors in computing systems*. 1994. ACM.

13. Rolland, K.H. and E. Monteiro, *Balancing the local and the global in infrastructural information systems.* The information society, 2002. **18**(2): p. 87-100.

14. Tiwana, A., *Platform ecosystems: aligning architecture, governance, and strategy*. 2013: Newnes.

15. Baldwin, C.Y. and C.J. Woodard, *The architecture of platforms: A unified view*. 2008.

16. Roland, L.K., T.A. Sanner, J.I. Sæbø, and E. Monteiro, *P for Platform: Architectures of large-scale participatory design.* Scandinavian Journal of Information Systems, Forthcoming.

17. Kimaro, H.C. and O.H. Titlestad, *Challenges of user participation in the design of a computer based system: The possibility of participatory customisation in low income countries.* Journal of Health Informatics in Developing Countries, 2008. **2**(1).

18. DHIS2.org. *Data Entry Forms*. [cited 2017 April 18th]; Available from: https://docs.dhis2.org/2.22/en/user/html/ch06s02.html.

19. Walsham, G., *Interpretive case studies in IS research: nature and method.* European Journal of information systems, 1995. **4**(2): p. 74-81.

20. Susman, G.I. and R.D. Evered, *An assessment of the scientific merits of action research.* Administrative science quarterly, 1978: p. 582-603.

Appendix 3 – Certificate of Completion DHIS2 Academy Tracker level 2 Rwanda

REPUBLIC OF RWANDA

MINISTRY OF HEALTH
P. O. Box 84 Kigali
www.moh.gov.rw

dhis2 Academy

USAID | RWANDA
FROM THE AMERICAN PEOPLE

msh
Management Sciences for Health

hisp Rwanda

University of Oslo

CERTIFICATE OF SUCCESSFUL COMPLETION

This is to certify that

Mr Magnus Li

Has successfully completed the

DHIS2 ACADEMY EAST-AFRICA 2016, Tracker-level 1.

22nd -26th August, 2016-Nobleza Hotel, kigali, Rwanda.

Department of informatics
P.O.Box 1080 Blindern
N-0316 OSLO, NORWAY

Ministry of Health.	HISP Rwanda	University of oslo