Development of an interactive tool to support the evaluation of clinic-based health information systems

by

Ruan Spies

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Supervisor: Prof SS Grobbelaar

Co-supervisor: Prof A Botha

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Declaration

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Date: March 2021

Abstract

Primary health care is considered the foundation of the health system and the principal vehicle for achieving good health and well-being for all people. A large number of challenges are faced in delivering high-quality care in South Africa's primary health care system due to numerous adverse factors, including the historic fragmentation of the health system, inadequate infrastructure and immense resource constraints. To mitigate these adverse factors, clinic-based health information systems (CBHIS) aim to consolidate information relevant to the primary health care environment from various stakeholders across multiple areas of interest. However, CBHIS also face various socio-technical problems which lessen their effectiveness. The evaluation of CBHIS allows for these problems to be identified and mitigated; it also helps in establishing trends of well-functioning aspects which may be disseminated for system improvement. Thus, supporting the evaluation of CBHIS would strengthen the primary health care system.

In this study, an interactive tool is developed to support the evaluation of CBHIS. The interactive tool is developed, refined and validated through multiple design cycle iterations, as informed by the Design Science Research framework. Various tool components are established by leveraging insights obtained from the Monitoring and Evaluation as well as Information Systems domain. These components are refined through conducting a theoretical case study of the Stock Visibility System and critically evaluated by multiple subject-matter experts to ensure the rigour of the development process and relevance to support evaluation.

The components are consolidated and implemented on a computer as the final interactive tool to support the evaluation of CBHIS. The interactive tool comprises three outputs which present a tangible set of interrelated evaluation concepts in a simple, structured and useful manner, namely, a concept inventory, responsive concept map and an evaluation support document. The interactive tool is demonstrated to illustrate its applicability and capacity to support the evaluation of CBHIS.

Opsomming

Primêre gesondheidsorg word beskou as die grondslag van die gesondheidstelsel en die belangrikste middel om goeie gesondheid en welstand vir alle mense te bewerkstellig. 'n Groot aantal uitdagings verhoed die lewering van hoë gehalte sorg in primêre gesondheid as gevolg van talle nadelige faktore, insluitend die historiese versplintering van die gesondheidstelsel, onvoldoende infrastruktuur en geweldige beperkings op nodige hulpbronne. Dit is *clinic-based health information systems* (CBHIS) se doelwit om inligting wat vir die primêre gesondheidsorg-omgewing van verskillende belanghebbendes relevant is, op verskillende terreine te konsolideer en sodoende te help om die nadelige faktore waarmee die gesondheidstelsel te kampe het, te verlig. Die stelsels het egter ook verskillende sosio-tegniese probleme wat die doeltreffendheid daarvan verminder. Die evaluering van CBHIS maak dit moontlik om hierdie probleme te identifiseer en te verlig; dit help ook om tendense vas te stel van goed funksionerende aspekte in die stelsels wat versprei kan word vir algemene verbeterings. Daar bestaan dus ‘n behoefte om die primêre gesondheidsorgstelsel te versterk deur die ondersteuning van die evaluering van CBHIS.

In hierdie studie word 'n interaktiewe hulpmiddel ontwikkel om die evaluering van CBHIS te ondersteun. Die hulpmiddel word ontwikkel, verfyn en bekragtig deur middel van veelvuldige herhalings van die ontwerpsiklus, soos ingelig deur die *Design Science Research* raamwerk. Verskeie komponente van die hulpmiddel word vasgestel deur gebruik te maak van insigte wat verkry word uit die Monitering en Evaluering asook die Inligtingstelsels domeine. Hierdie komponente word verfyn deur die uitvoering van 'n teoretiese gevallestudie van die *Stock Visibility System* en word krities geëvalueer deur verskeie kenners op die gebiede om die noukeurigheid van die ontwikkelingsproses en die relevansie vir evaluering te verseker.

Die komponente word op 'n rekenaar gekonsolideer en geïmplementeer as die finale interaktiewe hulpmiddel om die evaluering van CBHIS te ondersteun. Die interaktiewe hulpmiddel bevat drie funksionele uitsette wat 'n tasbare stel onderling verwante evalueringskonsepte op 'n eenvoudige, gestruktureerde en nuttige manier bied. Hierdie komponente sluit in: 'n konsepinventaris, 'n responsiewe konsepkaart en 'n ondersteuningsdokument vir evaluering. Die interaktiewe hulpmiddel word gedemonstreer om toepaslik te wees om die evaluering van CBHIS te ondersteun.

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Completing this study required more than academic support; thank you to my friends for supporting me throughout the writing process, listening to my frustrations and helping me stay focussed on the bigger picture. Thank you for the emotional support and your backing. Also, my deepest gratitude goes to my family for their love, support, and prayers throughout my years at university. To my parents, thank you for your continual sacrifice over the years and always going out of your way for us. You are an inspiration to me.

Finally, I want to honour Jesus who transformed my life, guided me to where I am now, and sustained me throughout the years at university.

Dedication

In loving memory of my grandmother, Enid van Rooyen. Your resilience, care and gratitude has deeply shaped me.

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List of acronyms and abbreviations

CBHIS	Clinic-based Health Information Systems
CMO	Context-Mechanism-Outcome
DSR	Design Science Research
HIS	Health Information Systems
ILE	Investigation Line of Enquiry
IS	Information Systems
M&E	Monitoring and Evaluation
MRQ	Main Research Question
PHC	Primary Health Care
SDG	Sustainable Development Goal
SME	Subject-Matter Expert
SRQ	Sub-research Question
TTF	Task-Technology Fit
WHO	World Health Organization

Chapter 1. Introduction

1.1. Background

In 2015, the United Nations published the Sustainable Development Goals (SDGs) – a "universal call to action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity" (United Nations, 2015, p. 18). The goals include 17 different, interconnected, international priorities. The third SDG, "Good health and well-being for people", is a broad-ranging goal that is broken down into a list of measurable targets. The health targets include: the significant lowering of maternal and infant death rates; the reduction of premature mortality due to non-communicable diseases; and achieving universal health coverage (Kwon, 2009; Paim et al., 2011; United Nations, 2015; World Health Organization, 2016; Yates, 2009).

In the first two years since the publication of the SDGs, the World Health Organization (WHO) recorded an increase of around 10% of the gross domestic product on the global health expenditure to US$ 7.8 trillion. There is however enormous disparity between the average health spending per person in high income countries, with an average of US$ 2937, compared to low income countries, averaging US$ 41 (World Health Organization, 2019). This extreme disparity is also seen within South Africa where the public health sector provides health care for 84% of the population and receives about the same amount of funds as the private sector, which serves only 16% of the population (South Africa. Department of Health, 2015).

The WHO reported that:

> South Africa also faces a formidable burden of disease, disproportionately impacting the poor. It has serious generalized human immunodeficiency virus and tuberculosis epidemics, a rapidly growing burden of noncommunicable diseases, high rates of injury and violence, and still unacceptably high levels of maternal and child mortality… The key issues facing the health sector are the redistribution of resources within the sector, improving the functioning of the public health system, and addressing the social determinants of ill-health, which have their roots in poverty and inequality (World Health Organization, 2017b, p. 4).

In a study about South Africa's health system by Coovadia et al. (2009), it is revealed that numerous of the country's current healthcare challenges are rooted in the country's history. South Africa's colonial history and systematic racial discrimination under apartheid directly contributed to poor healthcare. An obvious factor was that healthcare service delivery was provided at a significantly lower standard to a particular people. Additionally, a number of indirect factors played a role, including: how communities were organised; the poor living conditions within the communities; income inequalities; and the destruction of the basic family structure. Despite the abolition of the laws which enforced the aforementioned factors, the consequences are still evident throughout the country's health system (Coovadia et al., 2009).

A comprehensive definition of a health system is provided by the WHO:

> A health system consists of all the organizations, institutions, resources, and people whose primary purpose is to improve health. This includes efforts to influence determinants of health as well as more direct health-improvement activities. The health system delivers preventive, promotive, curative, and rehabilitative interventions through a combination of public health actions and the pyramid of health care facilities that deliver personal health care — by both State and non-State actors (World Health Organization, 2010, p. iv).

Taking a systems perspective provides an understanding that all the different facets of healthcare are interconnected, interrelated, and necessary to be seen as a whole. This also provides insight to the various role players that improvement of healthcare requires the collective improvement of all the facets involved, rather than attempting to optimise isolated elements (Griffin et al., 2016; White, 2015).

The WHO describes health systems in six core interrelated components which serve as a framework for taking a systems perspective of healthcare and are logically arranged into three categories. The first category comprises of the components that form the basis for the development, implementation and review of policies, regulations, and general health system operations. The second category is concerned with the components that are key inputs for the functioning of the health system. The final category can be seen as the immediate outputs of the system, those that directly influence the quality of care experienced by patients (World Health Organization, 2007, 2010). The aims of each of the building blocks are described in Table 1.1.

Table 1.1 Health system building blocks (World Health Organization, 2007)

Category	Building Block	Aims
Policy, regulatory and operation basis	Governance	Ensuring that the strategic policy frameworks are combined with effective oversight, establishment of appropriate regulations, incentives, and accountability measures.
	Health Information Systems	Having a system that ensures the production, analysis, dissemination and use of reliable and timely information of health determinants, health systems performance and health status for effective decision making at various levels in the health system.
Key inputs	Financing	Having a financing system that raises adequate funds for the health systems, ensuring that people can use the required health services while being protected from impoverishment associated with having to pay for them.
	Health workforce	Having a competent, responsive, fair, and efficient workforce with a sufficient number of workers that are fairly distributed to achieve the best health outcomes possible.
Immediate outputs	Service delivery	Delivering effective, safe, quality personal and non-personal healthcare to those who need it, when and where it is needed with minimum waste of resources.
	Access to essential medicines	Patients have equitable access to essential medical products, vaccines and technologies of assured quality, safety, efficacy and cost-effectiveness, and their scientifically sound and cost-effective use.

The six components provide a valuable basis for the development of indicators within each component, and across the health system. This serves as a basis for measuring system performance to identify, communicate and improve on potential problems, gaps or opportunities (World Health Organization, 2010). Examples for previous applications of the framework include: prioritising interventions (Tromp & Baltussen, 2012; Versteeg et al., 2013); identifying problems and planning solutions (Dickson et al., 2015; Kerber et al., 2015; Moxon et al., 2015; Sharma et al., 2015; Shoman et al., 2017); restructuring governance and finance (Mikkelsen-Lopez et al., 2011; Warren et al., 2013); and general strengthening of the health system (Drobac et al., 2013; Mounier-Jack et al., 2014; Nsubuga et al., 2010; Petersen et al., 2017).

In line with the global drive for universal health care (Kwon, 2009; Paim et al., 2011; World Health Organization, 2016; Yates, 2009), numerous international organisations, such as the WHO, and alliances, such as the Global Alliance for Vaccines and Immunization (Ravishankar et al., 2009), have been established. These role players assist in achieving SDG 3 through interventions in vertical programs, integrated approaches, or general support of countries' health system. The structuring, implementation and operation of a country's health system is, however, the responsibility of the ministry of health and should be realised based on the specific needs and available resources of the country (Frenk et al., 2010; Griffin et al., 2016; White, 2015; World Health Organization, 2010).

Since the democratisation of South Africa in 1994, the National Department of Health has prioritised Primary Health Care (PHC), which is considered the foundation of the health system (Bitton et al., 2016; Hone et al., 2018; Starfield et al., 2005; World Health Organization, 2008). PHC serves as the primary vehicle for reducing the disparity of care, achieving the SDGs and ensuring universal health care (Barron & Bennet, 2001; Republic of South Africa, 2004).

The emphasis on PHC by the South African National Department of Health is consistent with global health priorities. The Alma-Ata declaration of 1978, which was ratified by a large number of high-level, international leaders, provided a holistic philosophy of health with the emphasis on the criticality of PHC (Lawn et al., 2008). It has had a major, international impact regarding the emphasis of PHC (Galea & Kruk, 2019; Lawn et al., 2008; Walley et al., 2008; Wibulpolprasert et al., 2008). Forty years after the Alma-Ata declaration, an international recommitment to PHC took place at the International Conference of Primary Health Care. One hundred and twenty United Nations member countries signed the Astana Declaration which reaffirms the importance of PHC in achieving SDG 3 and universal health coverage (Hone et al., 2018; Park & Abrams, 2019; "The Astana Declaration: Time to Focus on Primary Health Care," 2018; The Lancet, 2018).

1.1.1. The positioning of primary healthcare in the South African health system

Health policy, regulation, legislation, and strategy are determined on two levels in South Africa, namely national and provincial. The National Health Council (NHC) and National Consultative Health Forum (NCHF) constitute the national governance of the health system. These entities are responsible for determining and ensuring the implementation, of national health policy for both the public and private sectors. The policy should protect, promote, improve and maintain population health (Republic of South Africa, 2004).

Similar to national governance, provincial governance comprises of a PHC and PCHF. The primary responsibility on the provincial level is related to the management of health services. The national health council does, however, have the power to intervene within provinces in the case of failure to fulfil directives and legislation (*Constitution of the Republic of South Africa*, 1996; Stevenson, 2019; World Health Organization, 2017b).

Health services are thus guided by policy mandates created by the national department and managed by provincial departments. The actual delivery of these health services takes place through the district health system, which is also considered the vehicle for delivering PHC (Barron & Bennet, 2001; South Africa. Department of Health, 1997, 2017, 2018a; South African Local Government Association, 2009; Williamson & Kaasbøll, 2009). The nine provincial departments are therefore broken into fifty-three districts with boundaries that are coterminous with the political and administrative municipal boundaries (Barron & Bennet, 2001).

The 1997 White Paper for the Transformation of the Health System in South Africa (South Africa. Department of Health, 1997) provided a set of principles on which the structuring of the district health system was based. The structure of the district health system is depicted in Figure 1.1. District and subdistrict management teams serve a governance role and provide guidance as to how things will take place. These teams report to the local government which helps with the implementation and administration of initiatives. Community based health services, PHC clinics and community health centres have the primary focus of promoting wellbeing and the prevention of diseases, but also do provide basic treatment. In more severe cases, patients are referred to district hospitals for more specialised treatment. Finally, private service providers are contracted on an ad-hoc basis by the management teams to provide support to clinics and community health centres (Barron & Bennet, 2001; Mahomed & Asmall, 2015).

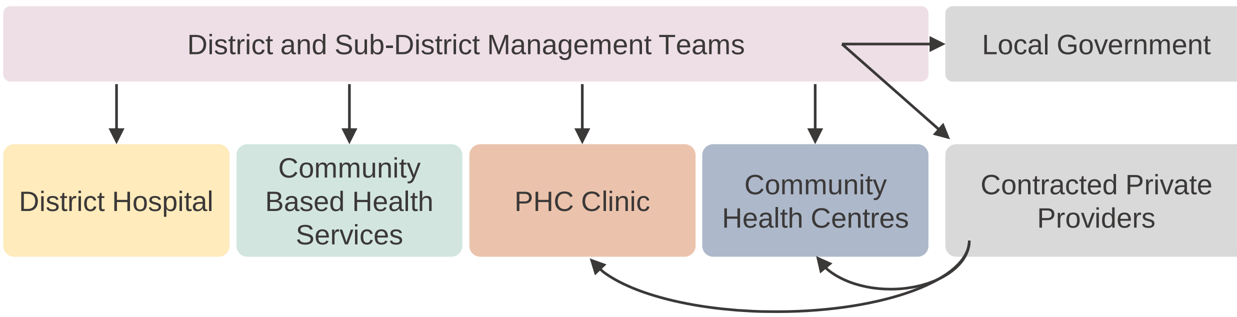


Figure 1.1 Structure of the district health system (Bheekie & Bradley, 2016)

The National Health Insurance Bill, introduced to parliament during 2019, aims to "achieve universal access to quality health care services in South Africa" (South Africa. Department of Health, 2019b, p. 2). PHC is a fundamental component to the Bill as it is the first level of contact of individuals, the family and community with the national health system and the entry point from which referrals for specialised care takes place (South Africa. Department of Health, 2019b). One of the criticisms of the Bill is that the existing PHC infrastructure is not able to handle the current demand without considering the definite influx in demand that would result from the Bill (Passchier, 2017).

On both a clinic and district level, challenges are faced which ultimately results in suboptimal health outcomes at a population level (White, 2015). These include the five major challenges depicted in Figure 1.2.

Figure 1.2 Primary health care challenges faced in South Africa (Maphumulo & Bhengu, 2019; South Africa. Department of Health, 2018b)

Various initiatives have been commissioned to improve the availability of medication in PHC. These include the Central Chronic Medicine Dispensing and Distribution, which aims to increase chronic medication availability by dispensing medicine from central locations, and the Stock Visibility System, which aims to create transparency of stock levels in clinics and allow for greater responsiveness to ensure medicine availability. Despite such initiatives, poor medicine availability remains a challenge in PHC (Barron et al., 2016; Ngcobo & Kamupira, 2017; Satoh & Boyer, 2019; Stop Stockouts Project, 2013; UNAIDS, 2019).

Old and poorly maintained physical infrastructures in clinics are inadequate for the delivery of quality health care. The misappropriation and inefficient usage of already limited financial resources along with poor maintenance result in the unavailability of adequate medical equipment and places constraints on basic physical resources such as personal protective equipment (Maphumulo & Bhengu, 2019). Furthermore, South Africa has a particular shortage of health care workers due to lack of skilled individuals and financial constraints (MacGregor et al., 2018). All these adverse factors contribute to the difficulty encountered in delivering quality health care and ensuring good health and well-being for people.

1.1.2. Health Information Systems as a means to strengthen the health system

The availability of reliable, comprehensive and timely information contributes to more effective management and decision making across the entire health system, thereby assisting in mitigating the aforementioned problems (English et al., 2011; Nicol et al., 2017; Rohde et al., 2008; Scott et al., 2014; World Health Organization, 2010, 2017b). As stated by the WHO, information is “essential for health system policy development and implementation, governance and regulation, health research, human resources development, health education and training, service delivery and financing” (World Health Organization, 2010, p. 44). Health Information Systems (HIS) refers to all the relevant systems that fulfil any of the four key functions depicted in Figure 1.3 and provides the foundation for the aforementioned information.

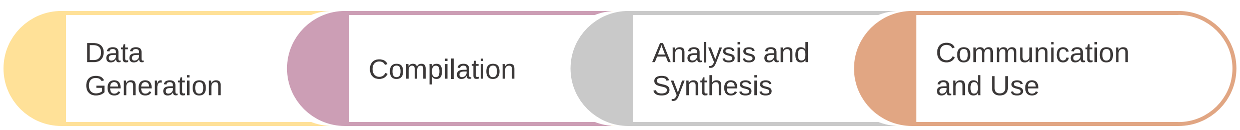


Figure 1.3 Key functions of Health Information Systems (World Health Organization, 2010)

Well-functioning HIS are able to consolidate all relevant partners and data to ensure that the stakeholders across the health system have access to reliable, authoritative, usable, understandable and comparative information (World Health Organization, 2010). This requires that a wide range of data, from various sectors, are leveraged within HIS to provide information spanning across multiple areas of interest for effective management and decision making. These areas may be described within five primary information categories, each comprised of a set of relevant information types, as summarised in Table 1.2.

Table 1.2 Information categories and types used in Health Information Systems (World Health Organization, 2010)

Information category	Specific information types
Health determinants	• Socioeconomic • Environmental • Behavioural • Genetic factors
Inputs to health system and related processes	• Policy and organization • Health infrastructure • Facilities and equipment costs • Human and financial resources

Information category	Specific information types
Outputs of the health system	• Availability • Accessibility • Quality and use of health information and services • Responsiveness of the system to user needs
Health outcomes	• Mortality • Morbidity • Disease outbreaks • Health status • Wellbeing
Health inequities	• Determinants • Coverage of use of services • Health outcomes • Key stratifiers

Clinic-based health information systems (CBHIS) refer to a subgroup of HIS that are specific to the PHC environment. The four key functions fulfilled in HIS, as depicted in Figure 1.2, are identical for CBHIS but limited to a smaller scope in the range of data that is generated and used.

1.2. Problem statement

The availability of reliable, comprehensive, and timely information for decision making in PHC necessitates that various aspects of CBHIS be capable of adequately generating, sharing, processing, and communicating relevant information which should be used correctly. This has proven to be particularly difficult in the South African PHC environment due to various socio-technical challenges: the existence of numerous segregated systems; the prevalence of paper-dependent systems; and the gap between design and reality (Adebesin et al., 2013; Braa et al., 2007; Heeks, 2006; Nicol et al., 2017; Rohde et al., 2008; South Africa. Department of Health, 2019a; South Africa. Department of Health & CSIR, 2019). These challenges result in poorer decision making throughout the health system and possibly lead to the detriment, rather than improvement, of the health system (South Africa. Department of Health, 2012; World Health Organization, 2018).

Both the *National Digital Health Strategy for South Africa* (South Africa. Department of Health, 2019a) and the *Global Strategy on Digital Health 2020-2024* (World Health Organization, 2020) convey the importance of evaluations to advance and strengthen all forms of digital health solutions. The evaluation of CBHIS provides a means of identifying specific problems within or across a system as well as learning from areas that work effectively, which allows for informed decision making surrounding the improvement of current systems and planning for future systems. Furthermore, the evaluation of these systems enables identifying aspects that work which may be disseminated for general improvements in the system (Ammenwerth et al., 2004; Andargoli et al., 2017; Crepaldi et al., 2018; Neame et al., 2020; Rossi et al., 2018; Sockolow et al., 2012; Yusof et al., 2008).

The need exists to support the evaluation of CBHIS and it is considered valuable to develop an interactive tool in aid of this endeavour.

1.3. Research questions and objectives

The aim of this study is to support the evaluation of clinic-based health information systems through the development of an interactive tool.

Based on this aim, the study is guided by the main research question (MRQ):

How can the evaluation of clinic-based health information systems be supported by an interactive tool?

Two additional sub-research questions (SRQ) were formulated to guide the review of literature:

> *SRQ 1: How can insights gained from the Monitoring and Evaluation research domain be leveraged to assist the development of an interactive tool for supporting the evaluation of CBHIS?*

The evaluation of CBHIS falls within the larger domain of Monitoring and Evaluation. This research question is answered through identifying important insights to formulate development requirements which assist the overall development of the interactive tool. These insights are synthesised and presented as a set of tool development requirements in Section 3.4.

> *SRQ 2: How can the application of an Information Systems theory inform a tangible set of evaluation concepts to aid the development of the interactive tool for supporting the evaluation of CBHIS?*

The development of the interactive tool requires a set of evaluation concepts grounded in the IS domain that may be appropriately leveraged to support the evaluation of CBHIS. In this study, an evaluation concept is considered an idea that is able to describe aspects of CBHIS in an evaluative manner. This research question guides the identification of such concepts from the Information Systems (IS) domain. The Task-Technology Fit (TTF) theory proposed by Goodhue and Thompson (1995) is examined to identify a tangible set of evaluation concepts from which the interactive tool is developed. The concepts are identified and catalogued into the evaluation concept inventory which is presented in Section 4.9.

Finally, to achieve the aim of this study and effectively answer the research questions, the research objectives described in Table 1.3 are pursued.

Table 1.3 Study objectives pursued in this study

Study objectives	Associated research question
1. To *conduct* a review of Monitoring and Evaluation literature, specifically: a. To *review* the role and characteristics of the complementary but separate functions of monitoring and evaluation; b. To *select* and *discuss* an appropriate paradigm which aligns with the aim of this study, and capable of guiding the tool development process; c. To *formulate* a set of tool development requirements based on the insights obtained in the pursuit of Objectives 1.a-b which guides the interactive tool development process and ensures that the interactive tool effectively achieves its aim; d. To *suggest* an appropriate Information Systems theory that aligns with the requirements formulated in pursuit of Objective 1.c – from which focussed insights may be drawn.	SRQ 1
2. To *conduct* a systematised literature review on the theory suggested in pursuit of Objective 1.d, specifically: a. To *discuss* the conceptualisation of the overall theory and the various components thereof; b. To *analyse* and *document* trends in how the theory has been applied since it's proposal; c. To *identify* and *catalogue* a tangible set of evaluation concepts into an inventory based on the application of the theory in extant literature.	SRQ 2
3. To iteratively *develop* and *evaluate* multiple tool components using appropriate methods. 4. To *conceptualise* the interactive tool design that consolidates all of the interactive tool components established in fulfilment of Objective 3. 5. To *develop* and *build* an interactive tool using appropriate software. The interactive tool should be practical and user-friendly in order to fulfil the requirements identified in Objective 1.d. 6. To *demonstrate* the functionality of the interactive tool in the context of supporting the evaluation of clinic-based health information systems. 7. To *recommend* areas of future research related to this study that may be pursued in the future.	MRQ

1.4. Overview of the research design

This study selects the Design Science Research framework to guide the overall research process. A summary of the research design followed in this study is depicted in Figure 1.4; it consists of four phases. The first phase defined the research by providing an overview of the background, establishing the research objectives (Chapter 1), and formulating the research methodology (Chapter 2). Phase two identifies the building blocks for the development of the interactive tool by reviewing the Monitoring and Evaluation domain (Chapter 3) as well as conducting a systematised literature review within the IS domain (Chapter 4). The third phase established the various tool components by conducting a theoretical case study and multiple interviews with subject-matter experts in order to leverage the insights gained (Chapter 5-Chapter 7). These former components are finalised in the last phase by the design and development of the interactive tool (Chapter 8), which is presented (Chapter 9), and the conclusion of the study (Chapter 10).

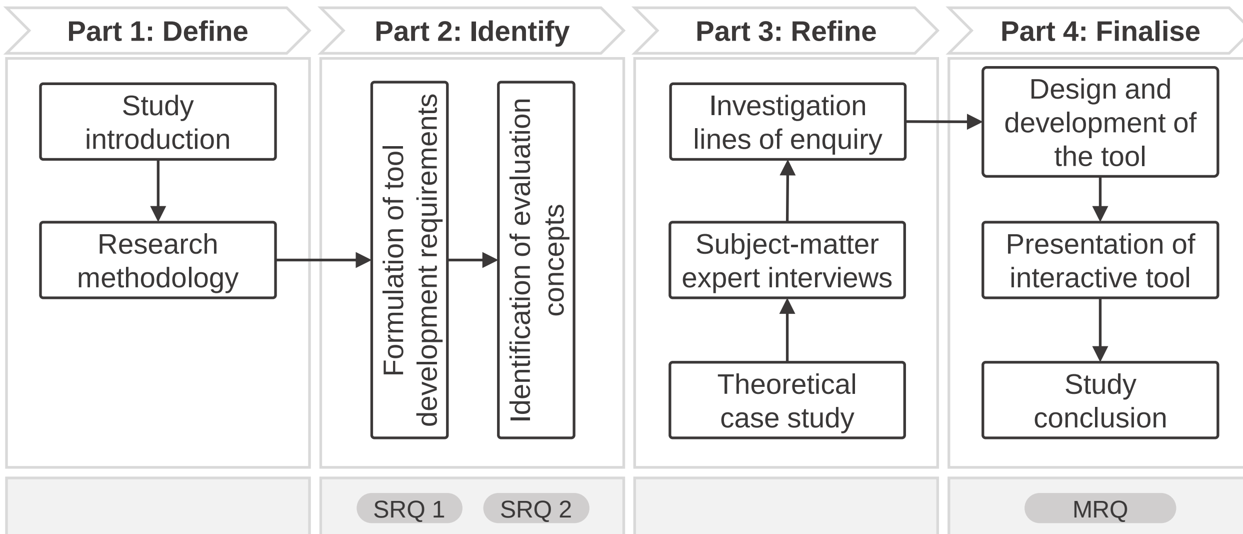


Figure 1.4 Summarised research design

A detailed discussion of the research design and its formulation is presented in Chapter 2.

1.5. Research scope

This study considers three primary overlapping domains for the development of the interactive tool. These are inferred from dissecting this study's main research objective (Section 1.3), as depicted in Figure 1.5, which additionally indicates the identification of the three primary domains of relevance to this study.

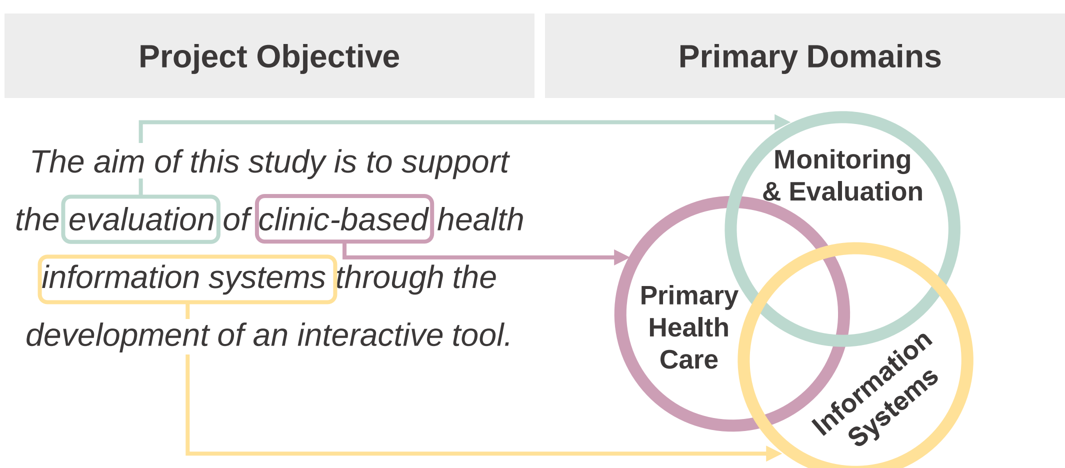


Figure 1.5 Project objective translated to the three primary domains of relevance for this study

Since the interactive tool developed in this study is concerned with supporting evaluation, the established domain of Monitoring and Evaluation provides important insight for the development of the interactive tool. CBHIS are the object of evaluation in this study. As discussed in Section 1.1.2, CBHIS are IS specific; they are specifically developed and used within the PHC environment. Consequently, both the PHC and IS domain provide fundamental and contextual insights for the tool development.

The effective extraction of appropriate information from these domains requires a structured, focused approach. In the following section, DSR is discussed which provides a means of conceptualising the design research paradigm and a structured approach for drawing information from the aforementioned domains.

Due to the complexity associated with each of the relevant domains, this study's scope is limited to the following:

Clinic-based health information systems. As discussed in Section 1.1.2, HIS refer to all of the systems that are used to generate, compile, analyse, communicate and inform decision making within the health system. This study is limited to CBHIS, which is concerned with the former mentioned systems within the PHC environment.

Health Information System evaluations. The evaluation of both IS at large, and HIS in particular, is a wide study field with a variety of focus in its different areas. Typical areas of study include usability and adoption of the technology; effects on structural or process quality; return on investments; organisational and social consequences of the systems; and identifying potential problems in the operation of the system (Ammenwerth et al., 2004). The aim of this study is not to develop such a framework or focus on specific aspects of the system; rather, the tool developed in this study is seen as complementary to these frameworks.

Theory-based evaluation approach. This study argues in line with the assertion from the realist evaluation paradigm that mechanisms (socio-technical aspects of CBHIS) producing context-bound outcomes (the capability of CBHIS to generate, share, process and communicate relevant information) may be explained by an underlying theory. Theory-based evaluations aim to develop such a theory; however, this study adopts a relevant, existing IS theory for the development of the tool, namely the TTF theory.

1.6. Ethical implications of the research

Individuals from industry were interviewed to evaluate different parts of this study which involved human opinions and therefore required ethical clearance from the Research and Ethics Committee of the University of Stellenbosch. This study had no significant ethical implication since none of the data or information collected was sensitive. Ethical clearance for the interviews was granted by the committee to the research project ING-2020-14921 on condition that:

1. Potential participants understood that their participation in the research was voluntary and could be withdrawn at any time before or after the research was completed;
2. Consent for participation was obtained from participants before data collection commenced;
3. Participants understood that they did not need to answer any questions they were not comfortable with;
4. Participants' personal information and all information disclosed by the participants remained confidential;
5. All information was stored securely.

The interviews were conducted during the COVID-19 pandemic, thus the principle of *primum non nocere* or first, do no harm was adopted; therefore, all interviews were conducted electronically in order to avoid physical contact.

1.7. Document outline

The document structure follows the logic of the research design, discussed in Section 1.4, with each chapter progressing according to the completion of the four parts of the research. In the following sections, an overview of each chapter is provided.

Chapter 1. Introduction

In this chapter, the background of th study is discussed along with an overview of PHC in South Africa's health system; the contribution of HIS to aid health systems is also examined. The research problem is provided followed by the formulation of the study aim, research questions and objectives as well the scope. An overview of the research design followed in this study is provided as an outline of the document.

Chapter 2. Research methodology

In Chapter 2, the research design and methodology followed in this study is presented. This chapter includes an in-depth discussion of the Design Science Research framework and a discussion of the research design based thereon. Furthermore, the various research methods incorporated into this study are discussed.

Chapter 3. Formulation of tool development requirements

SRQ 1 is answered in Chapter 3 by formulating a set of tool development requirements aligned with M&E domain. This is achieved by leveraging specific insights gained from overviewing M&E and discussing the realistic evaluation paradigm. The tool development requirements are presented in two categories. Firstly, functional requirements, which aim to ensure that the interactive tool effectively supports the evaluation of CBHIS by aligning with M&E principles and approaches. Secondly, identification requirements to support the identification of a tangible set of evaluation concepts from the IS domain by guiding the selection of an appropriate theory.

Chapter 4. Identification of evaluation concepts

SRQ 2 is answered in Chapter 4, by identifying and cataloguing evaluation concepts which emerge from the application of the TTF theory in literature into an evaluation concept inventory. An overview of the theory is provided followed by a scoping review which was conducted to identify evaluation concepts which emerge from the application of the theory in different settings. The findings of the scoping review are used to confirm the appropriateness of the TTF theory, and the evaluation concepts identified are catalogued into the evaluation concept inventory.

Chapter 5. Theoretical case study

The theoretical case study conducted to investigate the evaluation concepts in the interactive tool's application environment is discussed in Chapter 5. The process of identifying and analysing the appropriate case and resources is discussed. The results of the analysis are presented, and the insights obtained are used to adapt the evaluation concept inventory to be relevant for this study. Furthermore, the insights from the case study are used to inform the suggestion of relationships between the evaluation concepts which are visually depicted as a concept map.

Chapter 6. Subject-matter expert interviews

The semi-structured interviews conducted with a range of subject-matter experts is discussed in Chapter 6. Various subject-matter experts are identified and interviewed to validate, confirm and adapt the evaluation concept inventory and the suggested relationships. Furthermore, the insights obtained from the interviews are used to guide further development of the interactive tool.

Chapter 7. Investigation lines of enquiry

In Chapter 7, investigation lines of enquiry are formulated by leveraging structural attributes that emerge from the visual depiction of the relationships between evaluation concepts. The investigation lines of enquiry provide a robust structure which is consistent with the causal logic and presented in a simplistic way with only the necessary components. The high-level process for applying the investigation lines of enquiry is discussed along with a set of guidelines to aid the process.

Chapter 8. Design and development of the interactive tool

The process of consolidating the evaluation concept inventory, concept maps and investigation lines of enquiry into an interactive tool is discussed in Chapter 8. The contribution of each component is reviewed along with a specification of appropriate tasks tool users may perform to extract the value from the components. These insights are used to design the architecture of the interactive tool. Finally, the development of the interactive tool is discussed with details about the software used and an overview of the iterative development process followed.

Chapter 9. An interactive tool to support the evaluation of clinic-based health information systems

In Chapter 9, the motivation and purpose for the development of the interactive tool are reflected on and an overview of the overall development process is provided. Thereafter, the final interactive tool is presented by discussing the various components of the interactive tool, demonstrating its functionality, and describing how it may be used to support the evaluation.

Chapter 10. Conclusion and future work

In the concluding chapter, a summary of the research process completed in this study is provided and the realisation of the project objectives is discussed. Thereafter, the contributions and the limitations of the study, are discussed. Finally, suggestions are provided for future work based on this study.

1.8. Concluding remarks: Chapter 1

The evaluation of CBHIS provides a means of identifying and mitigating socio-technical problems in these systems as well as identifying aspects that work – which may be disseminated for general improvements in the system. The improvements to CBHIS contribute to more effective management and decision making across the entire PHC system. The aim of this study is to support the evaluation of clinic-based health information systems through the development of an interactive tool.

In this chapter, the research topic and case for this research is established. Furthermore, the research questions, objectives, scope, limitations and ethical considerations are clearly defined. In the following chapter, the research design and methodology followed in this study is discussed in detail.

Chapter 2. Research methodology

2.1. Introduction

The aim of this chapter is to discuss the research design and methodology followed in this study. The research design and methodology provide the means to achieve the project objectives and outcomes by guiding the overall process of collecting, analysing, synthesising and communicating information (Frankfort-Nachmias & Nachmias, 2008).

2.2. Research paradigms

Researchers are faced with a number of decisions to be made during the process of research, in both the approach followed and perspective taken. The manner by which these are decisions are approached will be influenced by the worldview, and thereby the research perspective, that is held. The selection of an appropriate research paradigm is therefore essential in the research process (Bryman & Bell, 2017).

Three major research paradigms were considered for this study: positivism, interpretivism and design. The three paradigms, as described by Vaishnavi and Kuechler (2004), are explained within three philosophical categories summarised in Table 2.1. The first category is ontology which describes the perspective one holds on the nature of reality. Epistemology is concerned with defining what may be regarded as acceptable knowledge. Finally, axiology describes what is regarded as valuable.

Table 2.1 Ontology, epistemology and axiology of different research paradigms (Vaishnavi & Kuechler, 2004)

Categories	Research Paradigm		
	Positivist	Interpretive	Design (This research)
Ontology What is the nature of reality?	Single reality that is knowable and probabilistic	Multiple realities which are considered to be socially constructed	Multiple, contextually situated alternative world-states that are socio-technologically enabled
Epistemology What is acceptable knowledge?	Objective knowledge which is detached from the observer	Subjective knowledge that emerges from researcher-participant interaction	Knowledge lies in the utility of the artefact which is objectively constrained construction within a context
Axiology What is of value?	Universal truth and prediction	Understanding	Control, creation, progress and understanding

Both the positivist and interpretive research paradigms may be described within the *natural science* realm as described by Simon (1996 cited Vaishnavi, Vaishnavi and Kuechler, 2015), as being concerned with knowledge about objects and phenomena in nature or society. In contrast, the design paradigm may be described as *science of the artificial* as it is concerned with the construction of objects and phenomena, referred to as *artefacts* which aims to meet specific desired goals (Vaishnavi & Kuechler, 2015). This study is grounded in the design paradigm.

The value of the artefact (interactive tool) created in this study lies in its ability to support the evaluation of CBHIS, which is to be validated by multiple subject-matter experts. This study acknowledges that multiple states may co-exist for any system under evaluation based on contextual and socio-technical conditions and should be considered in the development of the interactive tool. For example, an electronic health record system used by educated personnel in an urban area with good infrastructure may achieve positive outcomes when evaluated. In contrast, the same system used by an unskilled worker in a rural area with poor infrastructure will not achieve the same outcomes. Therefore, the same system exhibits both states due to the conditions. In wanting to make informed decisions to improve the system, it is therefore critical to consider the different contexts rather than making generalisations.

Within the design paradigm, knowledge lies in the utility of the artefact, i.e. to support the evaluation of CBHIS, and the development process which is considered to be objectively constrained within a context. In this study, the three primary domains of relevance discussed in Section 1.5 (PHC, M&E and IS) are considered to primarily shape this context.

Based on the grounding of this study in the design paradigm, Design Science Research is selected to inform the formulation of the research design. In the following section, an overview of Design Science Research is provided along with a discussion of its relevance to and implementation of in this study.

2.3. Design Science Research

Design Science Research (DSR) is a growing and evolving field which has emerged out of what was commonly understood as design research. Design research covers all design fields and is concerned with research into or about design itself. This includes the methods used, designers involved, and education required. In contrast, DSR is research that uses design as a research method (Baskerville et al., 2018; Herselman & Botha, 2020; Vaishnavi & Kuechler, 2015).

The general goal of DSR in IS related research is to create or contribute design heuristics and multiple types of knowledge to solve real-world problems. The knowledge is in the form of an *artefact*, which is a broad term that includes, but is not limited to, the various categories described in Table 2.2 (Baskerville et al., 2018; Dreschler & Hevner, 2016; Herselman & Botha, 2020; Vaishnavi & Kuechler, 2015).

Table 2.2 Examples of Design Science Research artefacts (Vaishnavi & Kuechler, 2004, updated 2015)

Artefact	Description
Constructs	The conceptual vocabulary of a domain
Models	Sets of propositions or statements expressing relationships between constructs
Frameworks	Real or conceptual guides to serve as support or guide
Architectures	High level structures of systems
Design Principles	Core principles and concepts to guide design
Methods	Sets of steps used to perform tasks—how-to knowledge
Instantiations	A realisation of constructs, models, methods, and other abstract artefacts within the application environment such as software products or implemented processes
Design theory	A prescriptive set of statements on how to do something to achieve a certain objective. A theory usually includes other abstract artefacts such as constructs, models, frameworks, architectures, design principles and methods.

Based on the description in Table 2.2, the interactive tool developed in this study contributes an instantiation which operationalises specific constructs, a model and methods into a software product to support the evaluation of CBHIS. This study contribution may further be positioned based on the DSR knowledge contribution framework presented by Gregor and Hevner (2013), and depicted in Figure 2.1. The framework identifies four quadrants determined by the level of *solution maturity*, which refers to the novelty of the artefact developed in DSR, and *application domain maturity,* which refers to the existing understanding of the problems faced within the application environment. This study is positioned as an improvement, developing a new solution (the interactive tool) for known problems (Section 1.2).

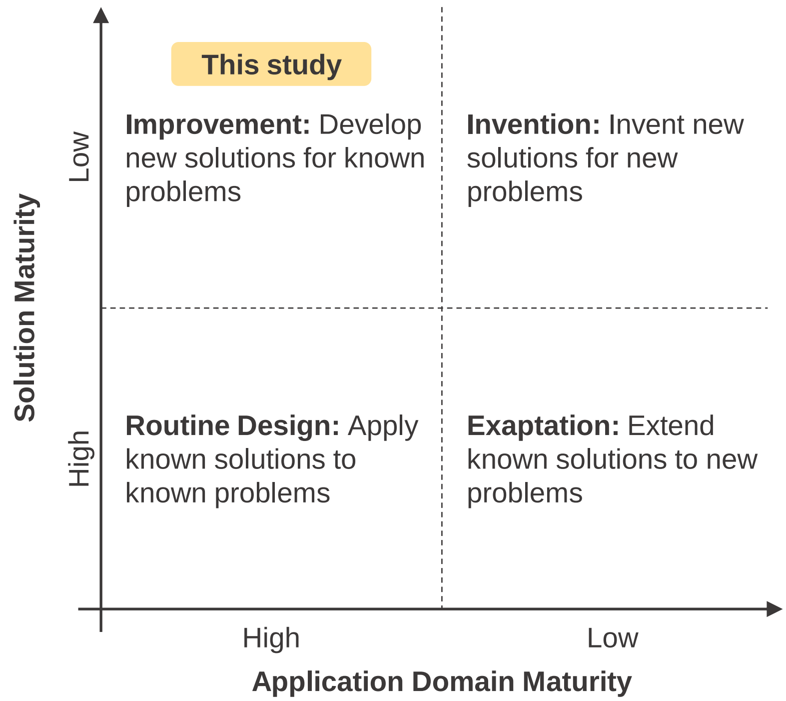


Figure 2.1 Positioning of this study within the knowledge contribution framework (Gregor & Hevner, 2013)

To aid the research process, seven guidelines which are grounded in the fundamental principles of DSR are considered. These guidelines are not mandatory and should not be applied in a rote manner (Meyer & Kenneally, 2012). Instead, researchers “must use their creative skills and judgment to determine when, where, and how to apply each of the guidelines in a specific research project” (Hevner & Chatterjee, 2004, p. 82). To this end, the application of the guidelines in this study is summarised in Table 2.3.

Table 2.3 Design Science Research guidelines *(Hevner & Chatterjee, 2004)*

Guideline	Description	Application in this study
Guideline 1: Design as an Artefact	Design-science research must produce a viable artefact in the form of a construct, a model, a method, or an instantiation.	This study aimed to develop an interactive tool, which may be described as an instantiation and is presented in Chapter 9.
Guideline 2: Problem Relevance	The objective of design-science research is to develop technology-based solutions to important and relevant business problems.	The study aims to address real problems in South African PHC, as discussed in Section 1.2; it repeatedly draws from the application environment in the development process to ensure that relevant problems are addressed.
Guideline 3: Design Evaluation	The utility, quality, and efficacy of a design artefact must be rigorously demonstrated via well-executed evaluation methods.	Various components of the interactive tool are iteratively evaluated to ensure the relevance and rigour thereof. A theoretical case study and multiple semi-structured interviews are incorporated for the evaluation. The application process of these methods is discussed in this chapter.
Guideline 4: Research Contributions	Effective design-science research must provide clear and verifiable contributions in the areas of the design artefact, design foundations, and/or design methodologies.	The final interactive tool and its utility are discussed in Chapter 9. The positioning of the interactive tool's contribution is discussed in this chapter, and the overall contribution of this study is discussed in Chapter 10.
Guideline 5: Research Rigour	Design-science research relies upon the application of rigorous methods in both the construction and evaluation of the design artefact.	The various methods that were applied in the construction and evaluation are discussed in this chapter.
Guideline 6: Design as a Search Process	The search for an effective artefact requires utilizing available means to reach desired ends while satisfying laws in the problem environment.	The interactive tool developed in this study leverages existing knowledge from the Monitoring & Evaluation domain as well as adapting an established IS theory to meet the needs in the problem environment.
Guideline 7: Communication of Research	Design-science research must be presented effectively both to technology-oriented as well as management-oriented audiences.	The research process discusses the various components of the interactive tool in sufficient detail for technology-orientated audiences. Careful attention is also given to the discussions, particularly the presentation of the final tool (Chapter 9) to ensure its relevance to management-orientated audiences.

Hevner (2007) defines a conceptual framework to assist in the understanding and execution of DSR – which is depicted in Figure 2.2. The framework consists of three cycles that form part of the DSR cycle: 1) the relevance cycle, 2) the design cycle, and 3) the rigour cycle.

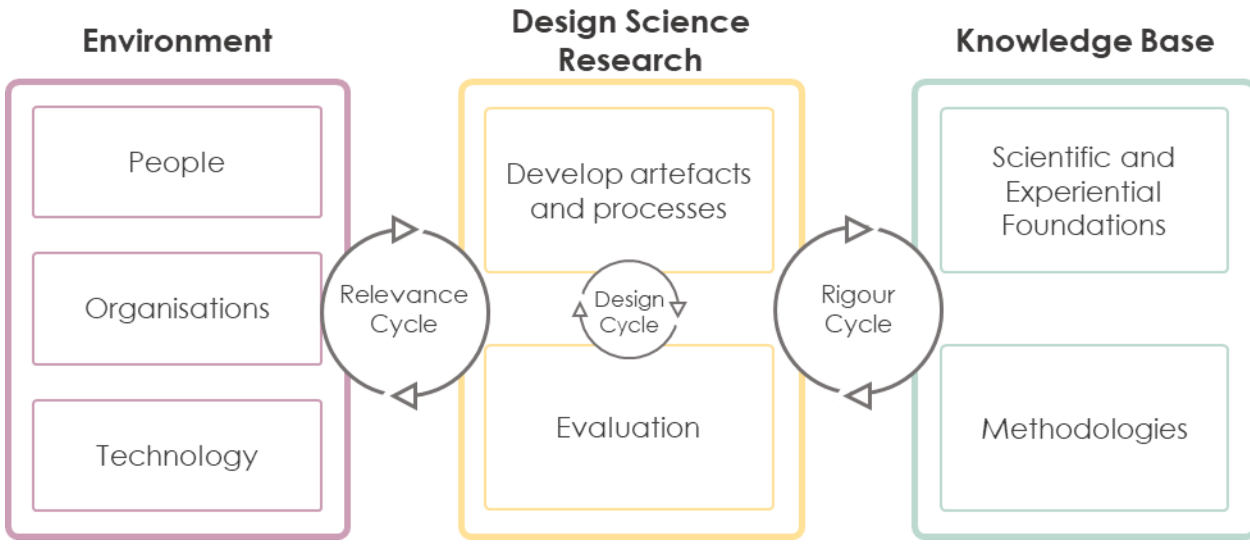


Figure 2.2 Design Science Research framework (Hevner, 2007)

In this framework, the relevance cycle triggers the research by providing the research problem or opportunity, the requirements, and acceptance criteria (Dreschler & Hevner, 2016; Hevner, 2007). This aims to ensure that the artefact is appropriate, applicable and implementable within the environment, i.e. relevant, by linking the artefact to the environment (Hevner, 2007). The environment provides the context and scope of the problem that is addressed by the research. It consists of the respective people, organisations and technology that is either planned for use or currently being used. The *goals, tasks, problems, and opportunities* that are identified within the environment assist to define the research (Hevner & Chatterjee, 2004, p. 79).

Rigour refers to the legitimacy of the research process and provides how the research *integrity and competency* is demonstrated (Tobin & Begley, 2004). The rigour cycle aims to ensure that the artefact is grounded in existing knowledge by drawing from, what is identified as, the knowledge base. This consists of but is not limited to, frameworks; theories; models; and instruments which may be used in the development or evaluation of the research artefacts (Dreschler & Hevner, 2016; Scribante et al., 2019). Additionally, the knowledge base consists of various methodologies which are used to guide the research process (Hevner & Chatterjee, 2004). Simultaneously, the research should also contribute to the knowledge bases through the dissemination of the research findings (Dreschler & Hevner, 2016).

The design cycle involves the rapid, iterative construction and evaluation of the artefact which draws from both the environment and knowledge bases as formerly discussed (Hevner, 2007; Hevner & Chatterjee, 2004). As noted by Dreschler and Hevner (2016), the evaluation of the artefact may take place in artificial settings, such as conceptual applications and experiments, or in the direct application environment.

In 2016, Dreschler and Hevner (2016) suggested the addition of a fourth *change and impact* cycle to the framework which considers the effect of the DSR project on the wider external environment. This is however not applicable in this study which considers the development of the interactive tool but not the implementation thereof.

Having overviewed DSR and the DSR framework as the selected means to rigorously guide the research process and facilitate the effective development of the interactive tool, the formulation of the research design for this study is discussed in the following section.

2.4. Research design

The DSR framework guides the execution of DSR to develop the interactive tool consisting of iterative design cycles which are informed and guided by considerations from the environment and knowledge base, ensuring the relevance and rigour of the final tool. The DSR framework identifies the environment as that which provides context and scope and the knowledge base which comprises the range of knowledge and information relevant to the artefact and development process. In this study, the three overlapping primary domains discussed in Section 1.5 are considered within these categories.

The intersection of these domains, i.e. M&E of IS within PHC, is considered the immediate and dominant environment of relevance (Section 1.5). Since this is an intersection of the three domains, each individual domain may also be drawn from to provide greater insight.

Since the interactive tool developed in this study is concerned with supporting evaluation, the established domain of Monitoring and Evaluation provides a solid knowledge base to guide and inform the development of the interactive tool. CBHIS are the object of evaluation in this study. As discussed in Section 1.1.2, CBHIS are IS that are specifically developed and used within the PHC environment. The IS domain is therefore also considered a valuable knowledge base.

The research objectives (RO) discussed in Chapter 1 were used to guide the formulation of the overall development approach for the interactive tool, depicted in Figure 2.3, based on the DSR framework. The interactive tool is developed in six design cycle iterations consisting of a development component, in which specific components of the interactive tool is developed, and an evaluation component, in which specific components of the interactive tool are reviewed to ensure utility. The rigour and relevance cycles, characteristic of DSR, are not considered separate from the design cycles but are rather incorporated within the first four design cycles by drawing from the knowledge base and environment.

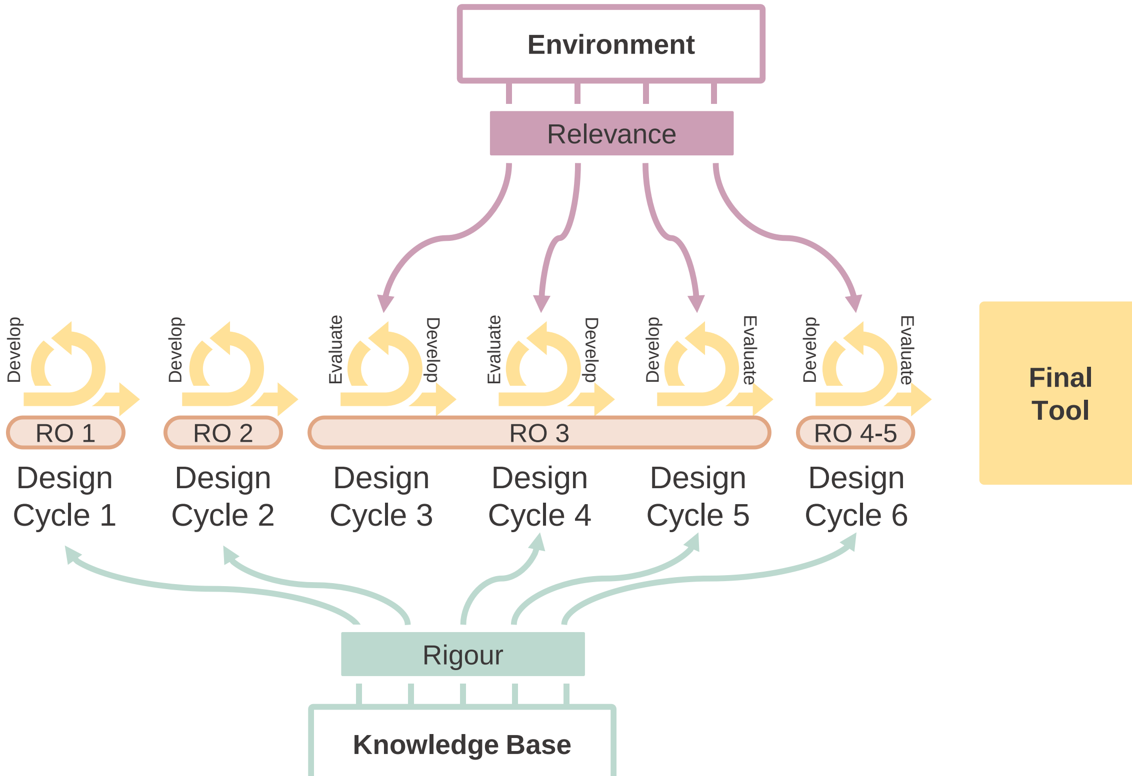


Figure 2.3 Overall approach for the development of the interactive tool

The colour scheme used in both Figure 2.2 and Figure 2.3 is adopted throughout this study when depicting and describing the overall development process or specific design cycle iterations. Yellow is used to describe either the process or the outputs related to design cycle iterations; purple is used for representing relevance and therefore also the application environment or aspects drawn from it; and blue is used for representing rigour and therefore also the knowledge base or aspects drawn from it.

The detail of the six design cycles as well as the corresponding relevance and rigour cycles is described within the context of this study's research design. The research design is *based on* the DSR framework (Section 2.3), *influenced by* the design paradigm (Section 2.2), *informed by* three primary overlapping domains (Section 1.5) and *supplemented by* various research methods to best answer the research questions.

Figure 2.4 provides an overview of the research design which is adapted from the methodological process suggested by Vaishnavi and Keuchler (2015) as well as the process model used by Peffers (2007). The research design is structured in four phases with the steps in each phase reflecting both the research process followed and corresponding with the chapters in this document. Additional elements are included in Figure 2.4 to indicate 1) how the research process is related to the former discussed design cycles, 2) the various research methods incorporated, and 3) where the research questions discussed in Section 1.3 are answered.

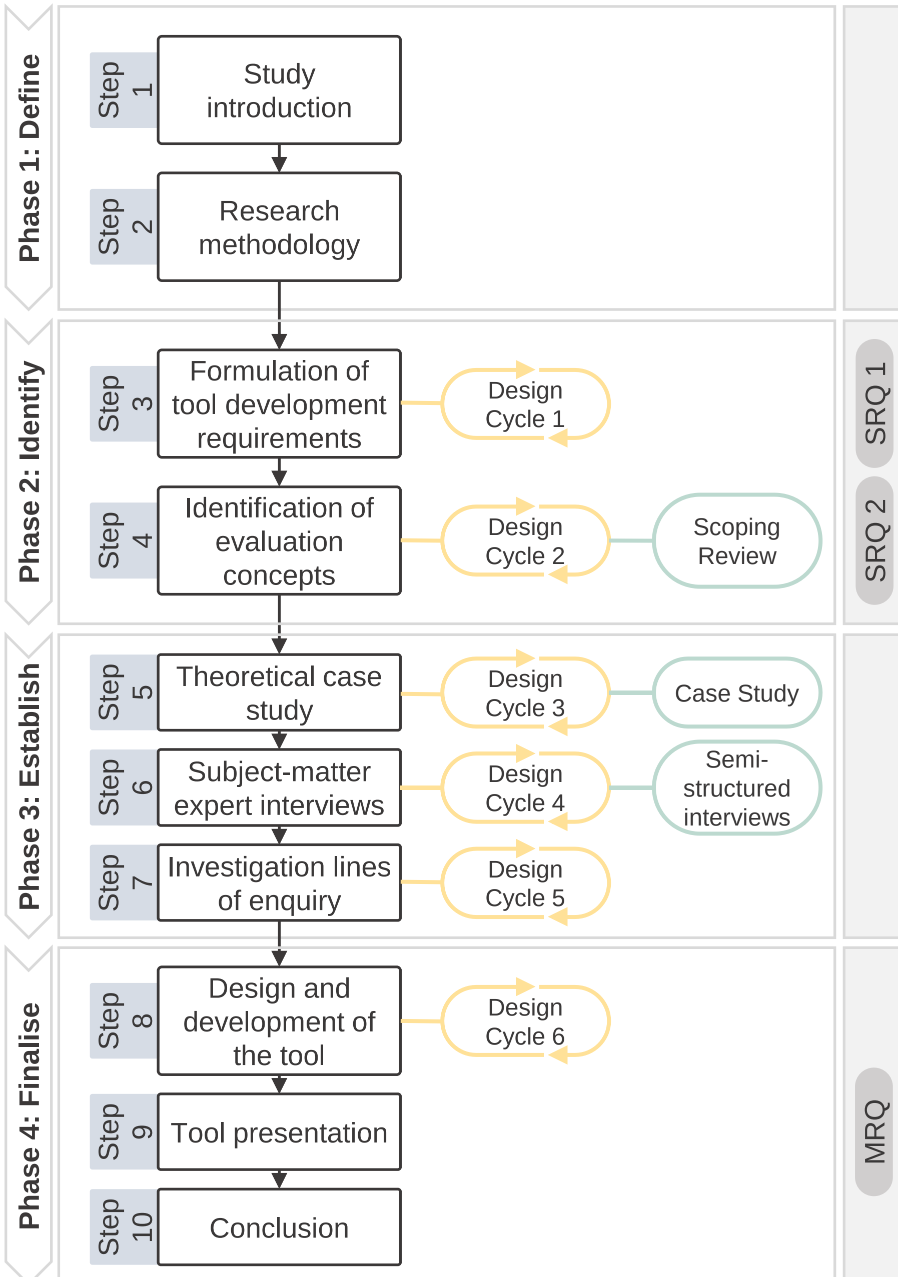


Figure 2.4 Detailed research design overview

In the following sections, the execution of the four major research phases is discussed along with an explanation of the corresponding design cycles and research methods.

2.4.1. Phase 1: Define the research

In the first phase, various aspects of this study were defined. In **step 1**, the review of healthcare in South Africa, the PHC system and IS used in these environments were used to establish the research problem, aims and objectives (Chapter 1).

In **step 2**, the researcher set out to formulate a research design that would effectively and innovatively meet the aims and objectives set out in this study, able to both guide the research process and development of the interactive tool. The DSR framework was selected to formulate the research design, consisting of multiple design iterations, and was supplemented with various research methods (Chapter 2).

2.4.2. Phase 2: Identify the building blocks for the development of the interactive tool

Phase 2 aims to answer the sub-research questions of the study and thereby identify established and context-appropriate information from which the interactive tool may be developed. This is achieved by reviewing literature from the M&E as well as IS domain, documented in Chapter 3 and Chapter 4.

Step 3 answers SRQ 1 by the completion of the first design cycle iteration, especially by leveraging insights from the M&E domain to formulate a set of tool development requirements which consists of functional and identification requirements. The role and characteristics of both monitoring and evaluation functions was overviewed (Section 3.2). This overview contributed to the formulation of the functional requirements which aim to ensure that the final tool effectively supports evaluation by aligning with M&E principles and approaches (Section 3.4). These requirements are pursued in Chapter 5-Chapter 8 and the fulfilment of these requirements are discussed in Section 9.5.

Additionally, the realistic evaluation paradigm was discussed (Section 3.3) and the specific insights from the discussion informed the formulation of the identification requirements (Section 3.4). These requirements aim to support the identification of a tangible set of evaluation concepts from the IS domain by guiding the selection of an appropriate IS theory.

Step 4 answers SRQ 2 by the completion of the second design cycle iteration, specifically by identifying and cataloguing evaluation concepts which emerge from the application of the Task-Technology Fit (TTF) theory in literature into an evaluation concept inventory. In this step, the TTF theory was selected in accordance with the former identification requirements and conceptualised by providing an overview thereof (Section 4.2). A scoping review of TTF literature was conducted (Sections 4.3-4.7) to firstly confirm the appropriateness of the theory based on the identification requirements (Section 4.8). Secondly, to identify and catalogue the evaluation concepts into an evaluation concept inventory (Section 4.9). The overview and outcomes of the scoping review is depicted in Figure 2.5.

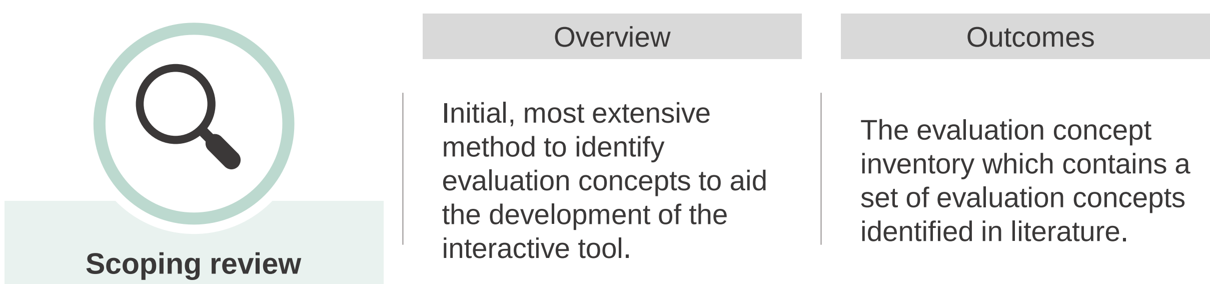


Figure 2.5 Overview and outcomes of the scoping review incorporated in this study (Arksey & O'Malley, 2005)

In 2005, Arksey and O'Malley (2005, pp. 3–4) published the influential article in which it was discussed that there exists ambiguity in the "plethora of terminology" which is used to describe various reviews of literature. The article makes the case that literature review methodologies provide a set of tools which may be used by researchers and that there does not exist an "*ideal type*" of literature review. In an attempt to provide descriptive insights to common types of reviews, Grant and Booth (2009) published a typology of 14 review types.

Moher, Stewart and Shekelle (2015) use a biological analogy to explain how different types of reviews are similar. Different types of biological species are considered part of the same family based on the presence of a commonly shared characteristic. They argue that different types of reviews should also be considered part of the systematic review family based on a commonly shared characteristic – the foundation in scientific method. This method is advised to be recorded in enough detail that it can be reproduced by others.

The scoping review is one such review type that can be considered *part of the family* (Grant & Booth, 2009). The first published framework (Arksey & O'Malley, 2005) for conducting scoping reviews argues for the review be used to develop an overview of domain knowledge. This is achieved by identifying the quantity of literature and analysing the key features of the literature. scoping reviews are of particular utility in synthesising a body of literature, often within a research field in terms of the literature's nature, feature and volume, as well as clarifying definitions and boundaries of concepts within the literature (Arksey & O'Malley, 2005; Martin et al., 2020; Peters et al., 2015).

The scoping review follows a standard, structured approach of analysing research to ensure the replicability of the process and the reliability of the results. This methodology is of particular utility in synthesising a body of literature as well as clarifying definitions and boundaries of concepts within the literature (Arksey & O'Malley, 2005; Peters et al., 2015). Scoping reviews may be used as a preliminary review to determine the value and scope of a full systematic review but may also be used in themselves to synthesise and disseminate research findings. The two former intentions for using the scoping review differ in the depth of the data analysis, but both follow the same procedure.

Since the publication of the first scoping review framework in 2005 (Arksey & O'Malley, 2005), the methodology has been enhanced to support the consistency in conducting and reporting on the review (Levac et al., 2010). The methodology has also been structured in such a manner to provide greater guidance in its implementation based on the purpose for conducting the review (Peters et al., 2015).

The main purpose of the scoping review conducted in this study was to identify a set of relevant evaluation concepts from a relevant body of literature (identified in Section 4.3.2), particularly, the application of the TTF theory within the study's scope and objectives. The procedure that was followed in the scoping review, adapted from Arksey and O'Malley (2005), is summarised in Table 2.4.

Table 2.4 Scoping review procedure (Arksey & O'Malley, 2005)

Steps	Description of application in this study	Section reported
Step 1: Identify the research question	SRQ 2 is identified as the research question since the scoping review aims to support answering this SRQ.	Section 1.3
Step 2: Identify relevant studies	A search strategy was formulated to identify relevant studies based on the research question. An exploratory search was conducted and used to refine the search to ensure both relevance and comprehensiveness. The search was then conducted on an appropriate electronic database. Further bibliometric analysis was conducted to ensure that all influential studies were included. The results of the search were well documented for further analysis.	Section 4.3.1

Steps	Description of application in this study	Section reported
Step 3: Select studies	The research questions were used to define the inclusion criteria, and inversely the exclusion criteria. The full set of articles identified in the previous step was iteratively reviewed against the criteria. The process was documented to indicate the basis on which articles were included or excluded.	Section 4.3.2
Step 4: Coding the data	A charting form was formulated based on the research questions to ensure the credibility of the data extraction process. The included studies were thoroughly analysed and coded.	Section 4.3.3
Step 5: Collate, summarise and report the results	The coded data from the previous step was exported into an appropriate format for further analysis. The coded data was analysed and synthesised to answer the research question. The output of the research questions forms the basis for the development of the framework.	Sections 4.4-4.9

The concepts identified were catalogued into the evaluation concept inventory (Section 4.9). This inventory and the tool development requirements provide a sufficient basis for further development of the interactive tool to establish the various tool components. This is discussed in the following section.

2.4.3. Phase 3: Establish the interactive tool components

In the third phase, three additional design cycle iterations are completed to establish the various tool components towards answering the main research question and achieving the aim of this study. This phase is documented in Chapter 5-Chapter 7.

In **step 5**, the third design cycle iteration was completed to, firstly, determine the relevance and applicability of the evaluation concepts identified in the previous phase. Secondly, to refine and contextualise the evaluation concepts to effective support the evaluation of CBHIS. Thirdly, to identify additional, relevant evaluation concepts. Finally, to suggest relationships between the set of evaluation concepts. These aims were achieved through conducting case study. The overview and outcome of the case study are depicted in Figure 2.6.

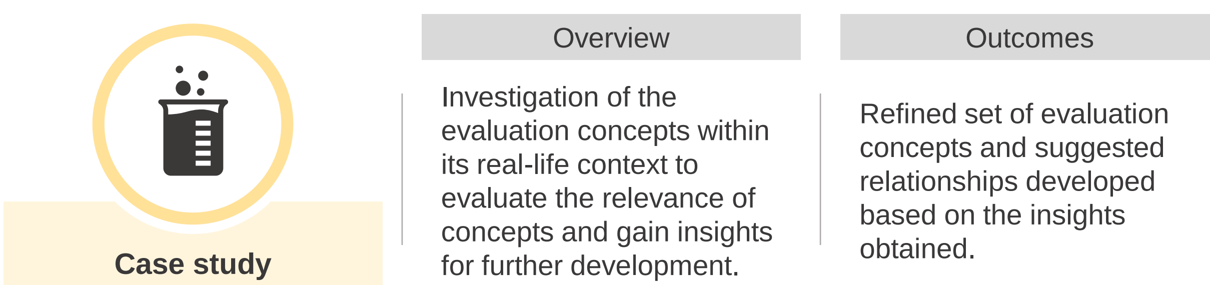


Figure 2.6 Overview and outcomes of the case study incorporated in this study (Yin, 2003)

Case studies are a popular method used to contribute to the knowledge and understanding of a wide range of topics and fields. As a research strategy, case studies allow for the investigation of complex phenomena whilst retaining holistic and meaningful characteristics of events being investigated. In the seminal work by Yin (2003), he emphasizes that “case studies are the preferred strategy when “how” or ‘why’ questions are being posed” (Yin, 2003, p. 1).

The value of case studies is that it allows the investigation of a contemporary phenomenon within its real-life context (Yin, 2003, p. 13) by using a variety of evidence – without the requirement of direct observations as opposed to conducting experiments where there is an intentional separation of context and the phenomenon under observation (B. Lee et al., 2007; Yin, 2003). This is of particular value within the DSR paradigm as the case study aids to establish relevance by drawing from the direct application environment. A case study was therefore selected to evaluate the evaluation concept inventory and further develop the interactive tool based on the insights obtained.

The case study methodology followed in this study is depicted in Figure 2.7; it was formulated based on the purpose of the study and guided by the principles specified by Yin (2003). This methodology provides the high-level process, the detail of how it is applied is discussed in Chapter 5.

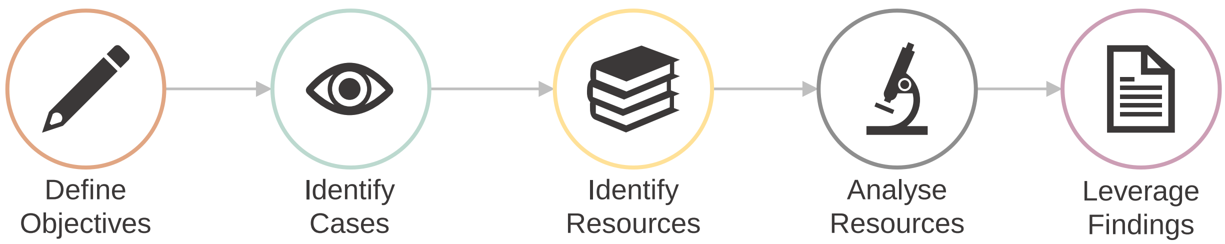


Figure 2.7 Methodology followed for the case study (Yin, 2003)

The first stage of the methodology is to define the objectives of the case study (Section 5.1). To achieve this objective, relevant cases and resources need to be identified, as set out by the second and third stages of the methodology (Section 5.2). The relevant resources are then thoroughly analysed (Section 5.3) following the generic six step approach suggested by Creswell (2018); this is depicted in Figure 2.8.

Figure 2.8 Data analysis process for qualitative research (Creswell, 2018)

The process is initiated by organising and preparing the various case study resources in a manner that is suitable and importing the data into the ATLAS.ti software. The reading of the data allows the researcher to become familiar with concepts and context, forming a basis for step 3. The data is revised and coded on the software as different concepts and themes emerge from the text. Specific meaning is associated to the coded data in step 4 in order to describe different themes and concepts which emerge from the data, primarily by referencing the concepts that form part of the evaluation concept inventory. In step 5, the data from ATLAS.ti is exported to Excel, arranged in an appropriate format, and linked to Tableau to visually represent the data. This data is then considered along with the concepts part of the evaluation concept inventory to interpret the data (Creswell, 2018).

In the final stage of the methodology, the findings of the data analysis process are leveraged to meet the aims of the design cycle iteration. In meeting the first three aims, adaptations were made to the evaluation concept inventory (Section 5.4). These adaptations contribute to the alignment of the evaluation concepts to this study such as to be both relevant and applicable to the application environment. Meeting the final aim resulted in the suggestion of relationships between evaluation concepts (Section 5.5). These relationships provide a means to consider the interrelated nature of the concepts to guide a more comprehensive evaluation of multiple socio-technical aspects of a system which influence each other.

The evaluation concept inventory and the suggested relationships form the first two components of the interactive tool. In **step 6**, the fourth design cycle iteration was completed to, firstly, validate the appropriateness of how the TTF theory has been applied in this study. Secondly, to confirm the relevance and rigour of two components. Thirdly to adapt these components to ensure its relevance and rigour. Finally, to obtain focused insights for further development of the interactive tool. These aims were achieved through conducting semi-structured interviews with multiple subject-matter experts (SMEs) and leveraging the findings. An overview of the interviews and the outcomes are depicted in Figure 2.9.

Figure 2.9 Overview and outcomes of the semi-structured interviews incorporated in this study (Creswell, 2018)

The semi-structured interview aims to be a guided conversation rather than a set of structured enquiries and therefore offers flexibility to both interviewer and interviewee (Rubin & Rubin, 2012; Yin, 2003). The conversation is typically guided by a discussion guideline, which is a predetermined line of inquiry based on the objectives of the interview. These may take the form of open-ended questions that allow the interviewee to describe both facts and their perception of the phenomena being studied. Based on the responses, the semi-structured interview provides the freedom to further explore specific elements of the response in a conversational manner which is of value to this study (Yin, 2003). These interviews provide a valuable means of both evaluating the interactive tool components as well as further exploring the relevant concepts which emerge in the interview, thus allowing insights to be obtained for further development.

A number of interview procedures have been suggested and are found to be similar (Creswell, 2018; Frankfort-Nachmias & Nachmias, 2008; Yin, 2003). This study selects the procedure suggested by Creswell (2018), which is summarised in Table 2.5.

Table 2.5 Semi-structured interview procedure (Creswell, 2018)

Stage	Implementation in this study
Stage 1: Define the purpose of the interview	Clearly formulate what the interviews aim to achieve. This should align with and support the overall research questions (Section 6.1).
Stage 2: Identify appropriate participants	Based on what the interviews aim to achieve, the potential participants be best suited for the interviews were identified (Section 6.2).
Stage 3: Select how the interview will be conducted	Due to the COVID-19 pandemic, all interviews were conducted via an online platform (Section 6.3)

Stage	Implementation in this study
Stage 4: Design an interview protocol	An interview protocol includes information about the interview, general instructions for conducting the interviews, as well as the specific questions to be asked. The questions were developed to answer the overarching research questions and probe for further insights. The protocol provides a means of ensuring that the interviews generate comparable data, despite being more open-ended, and achieving its objectives (Section 6.3).
Stage 5: Obtain participant consent	Participants were informed of the ethical implications related to their participation and consent was obtained before the interview.
Stage 6: Use recording procedures	The interviews were recorded, and supplementary notes were made which could be used for the analysis of the interview.
Stage 7: Use good interview procedures	The interviewer gave attention to listen more than speak, engage with the interviewee, and politely probe for further insights in the interviews.

Multiple interviews were conducted with a range of subject-matter experts which contributed to the overall rigour and relevance of the interactive tool components (Sections 6.4-6.6). The subject-matter experts evaluated 1) the appropriateness of the TTF theory application and the rigour of the application as well as, 2) the various components based on the relevance and utility in the application environment. The evaluation resulted in the confirmation, contextualisation and minor modification of the evaluation concepts and their suggested relationships.

Furthermore, the interviews contributed focused insights for further development of the tool which is pursued in **step 7** with the completion of the fifth design cycle iteration. This iteration leverages the insight from the interviews and the tool development requirements to formulate investigation lines of enquiry (ILEs), which is the third and final interactive tool component. The ILEs provide a robust logical structure that incorporates the interrelated nature of the concepts (Section 7.3) and provides practical guidelines for applying these (Section 7.4). The utility of the ILEs and the suggested process was confirmed in an ex-post review with the various SMEs (Section 7.5).

These three components provide the basis for finalising the interactive tool to support the evaluation of CBHIS and to this end are consolidated in the following phase to design and develop the final interactive tool, demonstrate its functionality, and report on the findings.

2.4.4. Phase 4: Finalise the interactive tool and report the findings

The final phase consists of three steps to finalise the interactive tool and report on the findings.

Having established the three tool components in the previous phase, in **step 8**, the sixth and final design cycle iteration completed to consolidate these components to design and develop the interactive tool. This is achieved by considering the contribution of each component and suggested tasks that allow users to interact with these components (Section 8.2). The findings are used to guide the design of the interactive tool architecture (Section 8.3). Furthermore, a set of user interface design principles were added to the tool development requirements (Section 8.4) which was used to guide the development of the interactive tool on the R coding language (Section 8.5).

Step 9 answers the main research question by presenting the final interactive tool to support the evaluation of CBHIS. The motivation and purpose of the interactive tool are discussed (Section 9.2) along with an overview of the overall development process followed in this study (Section 9.3). The final interactive tool consisting of usage instructions and three functional outputs which support the evaluation of CBHIS is demonstrated. The functionality of the various outputs is shown and description of how they support the evaluation given (Section 9.4).

The final **step 10** comprises the conclusion of the project. The research process is reviewed to show how the research questions were answered. The contributions, limitations and suggestions for future research are discussed, and the study is concluded with the researcher's personal reflections on the study.

2.5. Concluding remarks: Chapter 2

The research design followed in this study was developed *based on* the DSR framework, *influenced by* the design paradigm, *informed by* three primary overlapping domains and *supplemented by* various research methods to best answer the research questions.

The research design incorporates six design cycle iterations in which the interactive tool is iteratively developed and evaluated, establishing the relevance and rigour of the interactive tool by drawing from the application environment and knowledge base. These iterations are supported by various research methods, namely: a scoping review on the application of the TTF theory; a case study; and multiple semi-structured interviews.

This chapter concludes the first phase of the research design. In the following chapter, the formulation of the tool development requirements based on the review of the M&E domain is discussed. This commences the second phase of the study which aims to identify the building blocks for the development of the interactive tool.

Chapter 3. Formulation of tool development requirements

3.1. Introduction

This chapter answers SRQ 1, namely, *how can insights gained from the Monitoring and Evaluation research domain be leveraged to assist the development of an interactive tool for supporting the evaluation of CBHIS?*

The SRQ is answered through the completion of the first design cycle iteration in which insights from the overview of Monitoring and Evaluation (M&E) literature (Section 3.2) and the discussion on the realistic evaluation paradigm (Section 3.3) was leveraged to formulate a set of tool development requirements (Section 3.4). The requirements presented in this chapter aim to ensure that the interactive tool aligns with M&E principles and approaches to effectively meet the aim of the study and to this end assists in the development of the interactive tool.

3.2. Overview of Monitoring and Evaluation

In overviewing Monitoring and Evaluation (M&E), the two complementary but separate functions which typically serve different purposes, are unpacked. The Organization for Economic Co-operative Development defines monitoring as a “continuing function that uses systematic collection of data on specified indicators to provide management and the main stakeholders of an ongoing development intervention with indications of the extent of progress and achievement of objectives and progress in the use of allocated funds” (Organisation for Economic Co-operation and Development, 2002, p. 1).

The focus of monitoring is both on the progress that is made in the implementation of interventions as well as reviewing the progress against achieving the original objectives that were set out. The term *interventions* is used in the broader sense to refer to the subject under investigation. The monitoring process is typically done internally to provide feedback to stakeholders about the state of the intervention, supports accountability and allows management to plan appropriate strategies and actions to ensure progress towards the intervention objectives (Markiewicz & Patrick, 2016; United Nations Development Programme, 2009).

Reynolds et al. (2016) summarises four different types of monitoring based on their relationship for supporting management decision making. These may be incorporated at different stages of an intervention or used in conjunction to support different aspects of decision making. The four types are described in Table 3.1 along with an indication of the situations under which it is appropriate. The first two types are concerned with the state of an intervention before any action is taken on the system, whereas the latter two focus on the intervention’s response to specific actions taken.

Table 3.1 Monitoring types (Reynolds et al., 2016)

Monitoring type	Description	Situations when appropriate
Status and trends monitoring	The focus is on monitoring the state of an intervention, independent of actions to alter it. This is typically used identify a baseline which may be used when future actions are taken.	When no specific action is being considered and the purpose is to monitor state of the intervention over time.
Threshold monitoring	Monitoring is designed to inform decision making on how actions should be taken on the intervention.	When the information generated by the monitoring process will trigger a specific action.
Effectiveness monitoring	Once the relevant decisions are made to act on an intervention, this monitoring considers the consequences of those actions. This information may subsequently be used to inform future decision making.	When a specific action is planned and there is low uncertainty in the expected response to the action.
Adaptive management	Adaptive management is a framework for iterative decision making when there is large uncertainty in how a programme will respond to potential actions. The framework uses a quantitative process to combine monitoring and prediction models to quantify expected outcomes, thereby planning and implementing actions.	When a specific action is planned and there is medium or high uncertainty in the expected response to the action. This may also be in the case where alternative actions are considered to inform future decisions.

Evaluation, in its broad conceptualisation of making judgements about something, has been informally utilised by humans for thousands of years (Lance Hogan, 2007). The development of evaluation from an informal cognitive practice to an established, systematic discipline finds its origins in the education and manufacturing sectors of Great Britain and the United States between the late 18th and early 20th century. Evaluation has since been continuously developed and applied across all sectors with varying objectives and approaches (Rossi et al., 2004; Stufflebeam et al., 2000).

These different developments can be identified in the typical definition used in the modern conceptualisation of evaluation. The definition provided by the Organization for Economic Co-operative Development in this study, states that evaluation is:

> The systematic and objective assessment of an ongoing or completed project, program, or policy, including its design, implementation, and results. The aim is to determine the relevance and fulfilment of objectives, development efficiency, effectiveness, impact, and sustainability. An evaluation should provide information that is credible and useful, enabling the incorporation of lessons learned into the decision-making process of both recipients and donors (Organisation for Economic Co-operation and Development, 2002, p. 1).

Evaluations are often referred to as programme evaluations. Similar to *interventions*, the term *programme* refers to the subject of the evaluation. This therefore encompasses a broad range of projects including social interventions such as health, poverty, and criminal justice service programs as well as testing military hardware, drinking-water quality and the maintenance of roads. Despite this broad scope, the techniques used to determine the predefined aims are similar (Organisation for Economic Co-operation and Development, 2019; Rossi et al., 2018).

One of the most accepted and applied distinctions in evaluation purposes was introduced by Scriven (1967) who suggested the categories of formative and summative evaluation. Formative evaluations are conducted during the implementation or operation of a programme and aim to provide feedback which is used to improve the programme based on the evaluation findings. Formative evaluations answer the question *How is it working?* Summative evaluations aim to inform the decision of whether to continue with a programme or to make value judgements on important aspects of a programmes performance; it answers the question *Did it work?* (Madaus et al., 1983; Rossi et al., 2004).

Patton (2011), who developed the Utilisation-Focused Evaluation and Developmental Evaluation approaches, suggests six primary purposes for evaluation which are summarised in Table 3.2. Although these purposes are distinct, in practice, various evaluations with multiple purposes are often conducted simultaneously or in parallel with different aspects that are interrelated. For example, within a health environment, an evaluation of a digital health intervention may be commissioned by funders to judge the impact of health outcomes whilst the developers conduct an evaluation aimed at improving the intervention and using the findings of the former evaluation to aid the latter evaluation (Patton, 2011).

Table 3.2 Primary purposes and uses of evaluation (Patton, 2011)

Purpose	Priority questions	Common approaches
Judgement of overall value: Determine the value and future of the programme.	Does the programme meet the participants' needs? How do the outcomes compare to the costs? To what extent does the programme have merit?	Impact evaluation Cost-benefit analysis Summative evaluation
Learning: Aimed at the improvement of the programme.	What works and what does not? How can outcomes and impacts be increased? How can quality be enhanced?	Formative evaluation Participant feedback Appreciative Inquiry
Accountability: Demonstrate the management and efficiency of resources in attaining desired results	Are funds being used for intended purposes? Are goals and targets being met? Is the implementation following the approved plan?	Program audits Performance measurement Scorecards
Developmental: Accounting for the adaptation of programmes in complex, emergent and dynamic environments.	What is happening at the interface between what the programme is doing and what is going on in the surrounding environment? How is the programme affected by the larger systems within the environment?	Developmental evaluation Complexity systems Emergent evaluation

Purpose	Priority questions	Common approaches
Knowledge generation: Enhance general understanding and identify generic principles about effectiveness	What lessons are being learned? What are general patterns and principles of effectiveness across different aspects of the programme? What principles can be extracted to inform practice?	Cluster evaluation Meta-analyses Synthesis evaluation

The former discussion reveals similar yet distinct functions of monitoring and evaluation. In Table 3.3, monitoring and evaluation are considered across several features to summarise the differences and complementarities between the functions.

Table 3.3 Functional differences and complementarity between monitoring and evaluation (Markiewicz & Patrick, 2016)

Category	Monitoring	Evaluation
Main interest	Support management decision making and provide a means for accountability	Learning for future improvement and strategic decision making
Timing	Continuous	Periodic, at specific milestones
Scope	• Implementation, including day-to-day activities; what the programme produces, and immediate outcomes • Whether the programme is implemented according to plan • Use of funds and other resources • Immediate responses of program stakeholders • Performance against indicators and targets	• Achievement of objectives • Changes at outcome and impact of the programme • How well programme resources are used • Programme's fit to context, stakeholder needs, and policy environment • Overall quality and value of the programme • Likelihood of continuation and benefits from the programme
Resourcing	Embedded as part of the programme management process	Requires dedicated resources within the programme budget
Conclusions	Programme progress and performance issues	Insights from the evaluation and recommendations for improvement
Reporting	Regular, simple reporting	Detailed evaluation reports at agreed intervals, typically midterm and end term
Informational	Monitoring and evaluation draw on the same data sources but ask different questions and analyse it with different objectives.	
Organisational	Monitoring and evaluation data are often channelled through the same administrative unit within an organisation.	
Integrative	Monitoring and evaluation draw from a pool of common methods, tools and analytical skills with choices made according to need, timing, expertise, resources, and feasibility.	
Methodological	Monitoring and evaluation share similar processes and tools for structuring and planning, obtaining data, analysing, and making value judgements.	

As indicated by the last complementary feature in Table 3.3, both monitoring and evaluation require a systematic process to be followed to ensure its effectiveness, as well as the credibility and usefulness of the evaluation findings (Rossi et al., 2018). To this extent, a large number of approaches or methodologies have been formulated and are often structured as a framework or model, which provide both an overarching plan and step-by-step guide to its operationalisation (Markiewicz & Patrick, 2016). These approaches and methodologies are described within specific evaluation paradigms, which are the implicit or explicit set of beliefs which underpin the operationalisation of M&E (CREST, 2013).

The realistic evaluation paradigm is underpinned by the belief that the same intervention may achieve different outcomes due to different operating conditions. This belief aligns with ontology of the design paradigm in which this study is grounded, specifically that multiple states of reality coexist based on the socio-technical enabled context.

Having conducted an overview of the M&E literature, the realistic evaluation paradigm is further discussed in the following section in order to leverage insights from both Section 3.2 and Section 3.3 for the formulation of the tool development requirements.

3.3. Realistic evaluation

Realistic[1] evaluation is grounded in the realist tradition of scientific philosophy, which has been largely shaped the seminal works such as Hesse (1974), Harré (1972, 1987), Bhaskar (1975), Lakatos (1976). Realism emphasises the *mechanics of explanation*, and this explanatory nature aids to the generation and refinement of the body of scientific knowledge (Pawson & Tilley, 1997). To be a realist is to claim the existence of specific entities. Scientific realism asserts that these entities exist and function independently of their investigation. Critical realism is the extension of the scientific realism into the social science (Fleetwood, 2002).

Realistic inquiry has been widely applied in the social sciences (Haig & Evers, 2016), with seminal studies in areas such as philosophy (Collier, 1994), psychology (Greenwood, 1994), sociology (Archer, 1995; Layder, 1998) and economics (Lawson, 1997), emerging in the 1990s. In the field of evaluation, this approach was introduced by Pawson and Tilley (1997).

Realist evaluation is considered to be a theory-driven evaluation but differs from other theory-driven evaluation approaches as it is underpinned by a realist philosophy of science (Coryn et al., 2011). This evaluation approach assumes that social systems and structures are real and that the various people involved respond differently to interventions in different circumstances (Wong et al., 2016). In their seminal publication, Pawson and Tilley (1997) explain that the overall quest in applying the realistic evaluation is to have explanatory power, which is achieved by answering the main evaluation question “What works for whom in what circumstances?”. This differs from traditional evaluation approaches which aims to answer the overarching question “Does it work?” or “What works?” (Tilley, 2000). The theory therefore considers the theory of what causes change as the unit of analysis rather than whether interventions worked or not (Wong et al., 2016). This also empowers better informed decision making as it is understood that what works for

[1] The terms *realistic evaluation* (Pawson & Tilley, 1997) and *realist evaluation* (Pawson, 2013) are used interchangeably in this study.

some people in certain contexts may not work with others in their contexts (K. Nielsen & Miraglia, 2017; Wong et al., 2016).

As pointed out by Wong et al. (2016), realist evaluations may be used for many types of programmes and purposes. The purposes correspond with the categories identified in Table 3.2 and specifically include: the improvement of programme designs, improving efficiency, informing scaling decisions and aiding the understanding of programme outcomes. The selected purposes have significant implications for how the main evaluation question will be answered.

Pawson and Tilley (1997) suggest a diagrammatic matrix that may be used to summarise various aspects of evaluation paradigms. The matrix distinguishes two broad categories of consideration which are broken down into another level of detail to aid the explanation. The first category, the methodological strategy, is subdivided to explain the basics of the paradigm's nature (*epistemology*), the key technical aspects (*method*) and the paradigm's view on the nature of social reality (*ontology*). The second category, policy implementation, is divided to explain what the programmes aims to do (*programming*), how programmes are refined (*progress*) and how the findings are used for policy making (*utility*). The diagrammatic matrix summarising the realistic evaluation is depicted in Figure 3.1 and can be viewed as one continuous phrase.

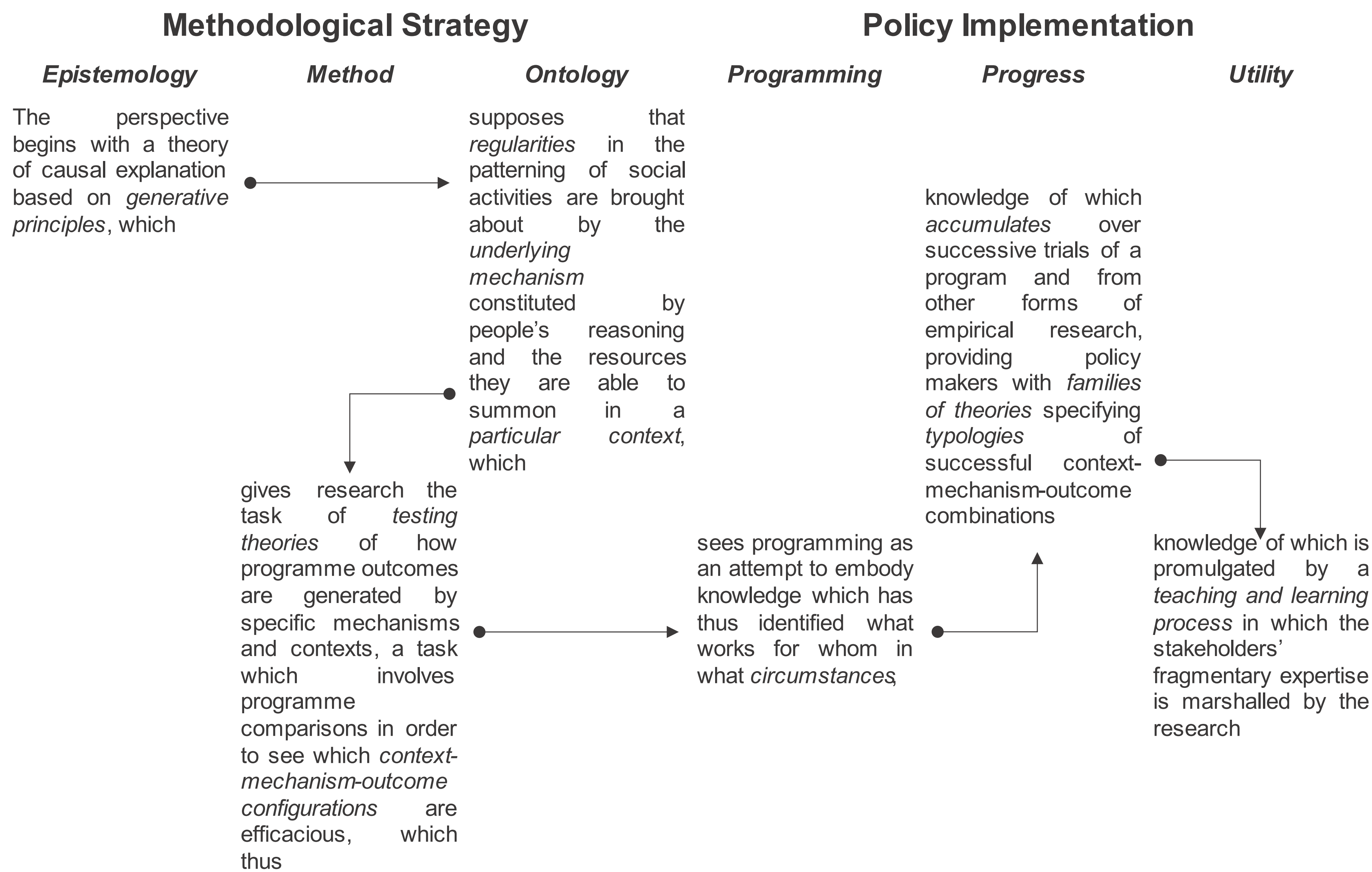


Figure 3.1 Overview of realistic evaluation (Pawson & Tilley, 1997)

Realists adopt a stratified view of social reality in which all human actions are considered to be embedded within a wider set of social rules and institutions at different layers. It is therefore necessary to understand regularities from this perspective. *Regularities* is a collective term used to explain the state of the object under investigation and includes concepts such as outcomes, patterns, and associations. The causal explanation for any regularity is based on the perspective that regularities are generated by change due to an underlying mechanism, constituted by people's reasoning and the resources which they draw on. This provides an important lens for understanding causality, not as residing in objects or individuals but in the complex relationships and organisational structures within the whole (Pawson & Tilley, 1997).

These underlying mechanisms provide an explanation as to *what it is about a programme* which makes it work by accounting for how both macro and micro processes constitute the program. The evaluation does therefore not aim to show that X produces Y, rather, it aims to explain why and how interventions have the potential to generate regularities (Pawson & Tilley, 1997). As emphasised by Pawson and Tilley (1997, p. 68-69), "[a] mechanism is thus not a variable, but an account of the make-up, behaviour and interrelationships of those processes which are responsible for the regularity". Since the mechanism is explanatory of regularities, different mechanisms may be identified for the same intervention depending on the investigation's objectives (Palm & Hochmuth, 2020).

The study by Dalkin et al. (2015) explores the various conceptualisations, applications, and further development of the mechanism concept. The authors point out that mechanisms are conceptualised differently across prominent studies (Astbury & Leeuw, 2010; Boudon, 1998; H. T. Chen, 2005; H. T. Chen & Rossi, 1987; Weiss, 1997) and applied in various ways (Elster, 1998; Greenhalgh et al., 2009; Vassilev et al., 2014). Although this shows flexibility in the application thereof, the variety of ways it has been applied shows that there is a lack of consensus on how mechanisms may be identified and applied in conducting evaluations (Handley et al., 2015; Marchal et al., 2012; Palm & Hochmuth, 2020).

In the realist view, the operation of the mechanism is completely dependent on the context. The context refers to the entirety of the "spatial and institutional locations of social situations together, crucially, with the norms, values and interrelationships found in them" (Pawson & Tilley, 1997, p. 216). The context is not a passive, background factor but is considered as acting on the individuals and influencing the mechanism. There is therefore always an interaction between the context and the mechanism, with certain factors in the context enabling, preventing, or determining how specific mechanisms operate. It is this interaction between the individuals, intervention and the context in which it is embedded that results in the outcome of the intervention (Pawson & Tilley, 1997). The same mechanism will therefore differ in impact based on the context in which it is introduced (Tilley, 2000).

With this understanding of how interventions work, the realist evaluation aims to answer the main evaluation question by *testing theories* of how the intervention *outcomes are generated by specific mechanisms and contexts* (Pawson & Tilley, 1997; Wong et al., 2016). These theories are expressed as context-mechanism-outcome (CMO) configuration, which is depicted in Figure 3.2.

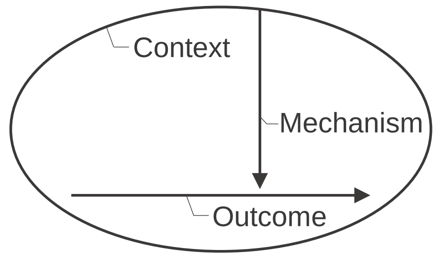


Figure 3.2 Basic depiction of the context-mechanism-outcome configuration

The CMO configuration can be applied on multiple levels of an interventions, pertaining to the complete intervention, parts thereof or different configurations embedded in another (K. Nielsen & Miraglia, 2017). This is an important characteristic as interventions typically bring about change on multiple levels with different stakeholders in different environments (Pedersen & Rieper, 2008). The formulation, refining and testing of the CMO configurations for interventions under evaluation allows for a more detailed understanding as to what works, for who and under what circumstances (Wong et al., 2016). Within the larger context of this study, numerous CMO configurations may be developed depending on the intended outcome to be considered for evaluation. A typical application of the realist evaluation may be to consider outcome as the quality of healthcare, the mechanism as the CBHIS and the context as specific conditions within the operating environment such as experience of using technology, regulations around the technology and the culture accepting new technology.

Pawson and Tilley emphasise that the usage of the realist evaluation does require effort from the evaluator to understand, view the intervention through the lens of and conduct the evaluation in line with realist evaluation paradigm. The authors provide broad guidelines for the implementation of the realist evaluation with the acknowledgement that the application thereof will require adaptation based on the specific objectives and characteristics of the evaluation (Pawson & Tilley, 1997). It has however been widely noted that, in the attempt to formulate a generic approach with leeway for specific application, the realistic evaluation lacks clear methodological guidance (Archibald et al., 2018; Gilmore et al., 2019; Haunberger & Baumgartner, 2017; Marchal et al., 2012).

Having discussed the realistic evaluation paradigm, specific insights obtained from this discussion as well as the overview of M&E literature are leveraged to formulate a set of tool development requirements which is discussed in the following section.

3.4. The tool development requirements

The tool development requirements are formulated based on the former overview of M&E and discussion of the realistic evaluation. These requirements assist the development of the interactive tool by providing a requirement which aim to ensure that the interactive tool aligns with M&E principles and approaches. The tool development requirements consists of two categories, namely functional and identification requirements which are detailed in the following sections.

3.4.1. Functional requirements

The functional requirements (FR) are specifications that need to be exhibited by the interactive tool to ensure it effectively supports evaluation by aligning with M&E principles and approaches. These requirements are presented in Table 3.4, along with the specific insights obtained in this chapter from which they were derived.

Table 3.4 Presentation of functional requirements

ID	Insight Category	Insights obtained in this chapter	Resulting development requirements
FR1	Language	The discussion of the literature provides a *language* that describes a way of thinking about and discussion of constituents within this study as well as that which this study aims to achieve.	The interactive tool should use and adapt terminology in a manner consistent with M&E language, specifically that of the realistic evaluation, and should empower users to communicate findings in a manner consistent with "what works, for who and under what conditions".
FR2	Structure	The insights related to the *structure* incorporated in the interactive tool and its application approach stem from overlapping observations within the discussion. A consistent logic that emerges across the M&E domain is that, if an evaluator wants to gain insight about X then it is necessary to consider aspects $Y_1, Y_2, Y_3, \ldots$ related to the intervention; this is referred to as causal logic.	The interactive tool developed in this project requires a robust structure which is consistent with the causal logic.
FR3	Implementation guidance	The realistic evaluation was formulated without rigid rules of how it should be applied such as to give the evaluators flexibility to adapt and apply it in their context based on their specific needs. A prominent criticism discussed in this chapter was however that there was the lack of methodological guidance in applying different aspects thereof, which ultimately limits its utility. Similar to the realist evaluation, the interactive tool developed in this study aims to provide application flexibility to investigators but, in accordance with the selected design science paradigm (Section 2.2), utility of the interactive tool is a necessity.	The interactive tool should provide sufficient implementation guidance to ensure its utility while not over-constraining the interactive tool.
FR4	Explanatory approach	The realistic evaluation was discussed in further detail as its premise of identifying "what works for who under what circumstances" and provides a valuable perspective for describing the state of CBHIS. This explanatory approach to evaluation provides greater insights to project stakeholders and empowers improved decision making from the findings.	The interactive tool should present concepts and guide the evaluation process to ensure that the findings are able to be communicated in an explanatory manner.

The second category of requirements is discussed in the following section.

3.4.2. Identification requirements

The identification requirements (IR) aim to support the identification of a tangible set of evaluation concepts from the IS domain by guiding the selection of an appropriate IS theory. These requirements were formulated based on two primary insight categories that are closely related, namely *CMO configurations* and *Underlying theory*. As discussed in this chapter, the *CMO configurations* provides a way to consider an intervention, viz. interventions consist of underlying mechanisms which generate certain outcomes under certain conditions. Since this study aims to support the evaluation of CBHIS itself rather than its impact, it borrows from the rationale of the CMO configurations but adapts it to best suit the objectives of this study.

Similar to realistic evaluation, the researcher's stance in this study is that outcomes (the capability of CBHIS to generate, share, process and communicate relevant information) are produced by underlying mechanisms (socio-technical aspects of CBHIS) within a specific context (users, role, nature of tasks, etc.). This is depicted in Figure 3.3 to show the relation of the CMO components to the context of this study. Furthermore, this study argues in accordance with the proposition that there exists an underlying theory that may be used to explain the mechanism which generates the outcome within a context. Wong et al. (2016) notes that the theory adopted within the scope of the realistic evaluation (describing what works for who under what conditions) does not have to be realist in nature to be used. Theories that are deemed viable for explaining the phenomena may be further developed or adapted to best describe phenomena within the CMO configuration and suit the specific evaluation objectives.

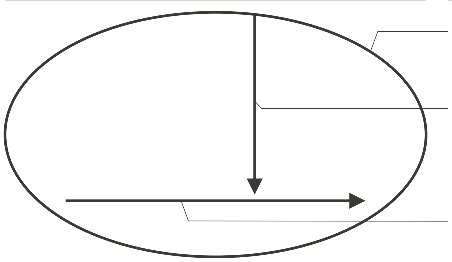
CMO Depiction	CMO Components	Study Context
	**Context**	Users, role, nature of tasks etc.
	Mechanism	Socio-technical aspect of the CBHIS.
	Outcome	The capability of CBHIS to generate, share, process and communicate relevant information.

Figure 3.3 Depiction of context-mechanism-outcome configuration in this study context

In this study, the proposition of the underlying theory provides a means of drawing focussed insights from the IS domain so as to identify a tangible set of evaluation concepts from the theory for incorporation in the interactive tool in order to answer sub-research question 2. Rather than empirically developing a theory, this study aims to select an existing IS theory or model that may be adapted to suit the study objectives. The theory incorporated in this study should therefore be reflective of the real-world scenario and contain sufficient conceptual content to fulfil the former function.

These insights are leveraged along with the overall study objective and research approach to formulate the identification requirements that aim to support the identification of a tangible set of evaluation concepts from the IS domain by guiding the selection of an appropriate IS theory. These requirements are presented in Table 3.5 along with the rationale for each requirement.

Table 3.5 Presentation of identification requirements

ID	Development requirements	Requirement rationale
IR1	The theory should align with the overall emphasis of this study which considers PHC stakeholders in their environment utilising CBHIS to perform appropriate tasks.	Since numerous models/theories exist within the IS domain, this requirement aims to ensure that the ones selected align with the objective of this study.
IR2	The theory should be widely accepted within the IS domain and applied regularly since its proposal. These factors may be tested by considering the discussion and application of the theory in peer-reviewed studies over time.	This criterion aims to ensure both the rigour (acceptance) and the relevance (consistent application) of the theory, and ensures it is consistent with the Design Science paradigm selected in this study.
IR3	The theory should have been applied across a wide range of systems.	This criteria firstly ensures that the theory is adaptable to different contexts, which allows its adaptation for this study. Secondly, since this study aims to build the interactive tool based on concepts related to the selected theory, the widespread application may provide a more diverse set of evaluation concepts to include as well as greater insight to how the theory may be adapted.
IR4	The theory should contribute sufficient explanatory power which may be checked by the nature (can they be used to explain rather than simply measure?) and the range (are there enough types of concepts to effectively describe the phenomena?) of the concepts.	The explanatory power of the concepts is an important requirement for the development of the interactive tool (see FR4) and the selected theory should therefore provide a sufficient basis to enable this.

In the following section, this chapter is concluded by discussing how the tool development requirements answer SRQ 1 and how these are used in the rest of the study.

3.5. Concluding remarks: Chapter 3

In this chapter, SRQ 1[2] was answered through the completion of the first design cycle iteration depicted in Figure 3.4; specifically by leveraging insights from the M&E domain to formulate a set of tool development requirements. These requirements consist of two categories which both aim to ensure that the interactive tool aligns with M&E principles and approaches and to this end assist the development of the interactive tool.

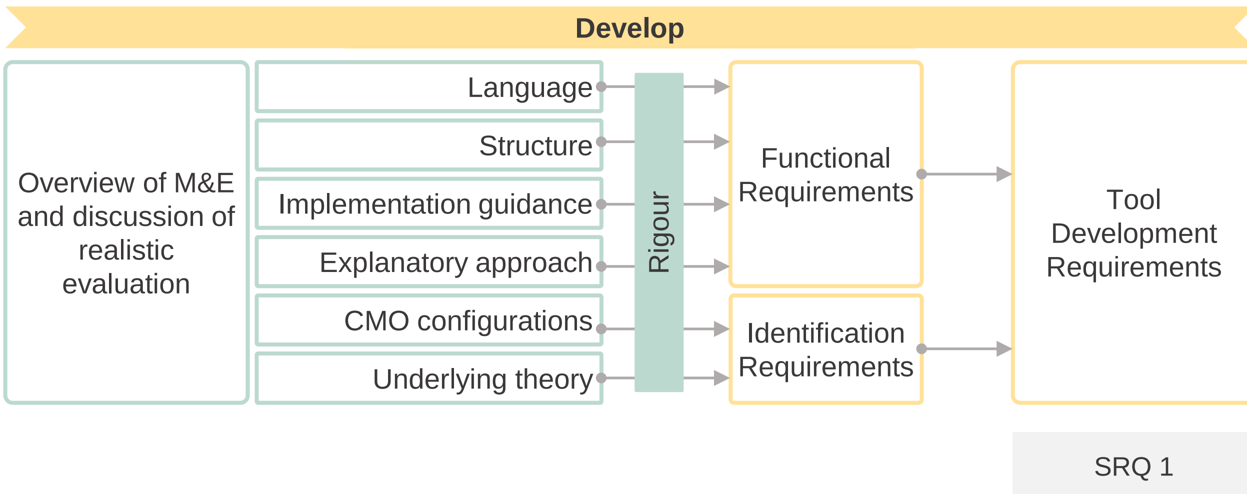


Figure 3.4 Completion of the first design cycle iteration

The set of tool development requirements is presented in two categories: firstly, functional requirements which are specifications that the interactive tool is required to exhibit in order to ensure it effectively supports evaluation by aligning with M&E principles and approaches These requirements are pursued in Chapter 5-Chapter 8 and the fulfilment of these requirements are discussed in Section 9.5.

Secondly, identification requirements which aim to support the identification of a tangible set of evaluation concepts from the IS domain by guiding the selection of an appropriate IS theory. In the IS domain, the Task-Technology Fit (TTF) theory proposes that if the task characteristics *fit* the technology characteristic and the technology is utilised, it will result in performance impacts. This conceptually aligns with the discussion of how CMO configuration is considered in this study. The TTF theory is therefore further explored and discussed in the following section to provide background to the theory, confirm the appropriateness for selection and ultimately identify a set of tangible evaluation concepts for the interactive tool.

[2] SRQ 1: How can insights gained from the Monitoring and Evaluation research domain be leveraged to assist the development of an interactive tool for supporting the evaluation of CBHIS?

Chapter 4. Identification of evaluation concepts

4.1. Introduction

This chapter answers SRQ 2, namely, *how can the application of an Information Systems theory inform a tangible set of evaluation concepts to aid the development of the interactive tool for supporting the evaluation of CBHIS?*

SRQ 2 is answered through the completion and discussion of the first design cycle iteration in this chapter. The Task-Technology Fit (TTF) theory introduced in Section 3.5 is conceptualised by providing an overview thereof (Section 4.2). This is followed by a discussion of the systematised review of TTF literature (Sections 4.3-4.7) which was pursued to firstly confirm the appropriateness of the theory based on the identification requirements (Section 4.8). Secondly, to identify and catalogue evaluation concepts which emerge from the application of the TTF theory in literature into an evaluation concept inventory (Section 4.9), thereby answering SRQ 2. Sections 4.2-4.4 was published in a special volume of *Lecture Notes in Computer Science* by Springer (Spies et al., 2020).

4.2. Overview of the Task-Technology Fit theory

"Models are ways to structure what we know about reality, to clarify understandings, and to communicate those understandings to others. Once articulated and shared, a model can guide thinking in productive ways" – Dale L. Goodhue

The TTF theory proposed by Goodhue and Thompson (1995) may be expressed as a simple model consisting of four components as depicted in Figure 4.1. The model provides a lens of technology usage and the value that it creates. In a setting where technology is used by individual's to perform certain tasks, or sets of tasks, the model's premise is that the value/performance of technology is created by 1) the alignment, or fit, of the task requirements and the technology characteristics that allow a user to perform the tasks; 2) its effective utilisation (Goodhue, 1998; Goodhue et al., 2000).

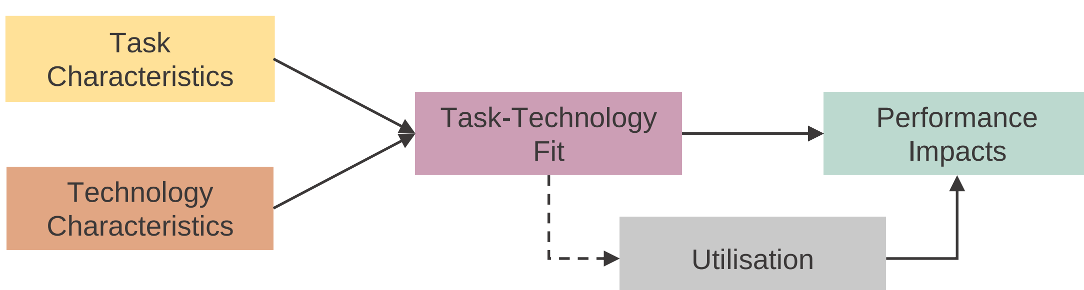


Figure 4.1 Basic Task-Technology Fit model (Goodhue & Thompson, 1995)

Tasks refer to the totality of physical and/or cognitive actions and processes done by individuals in a given environment. Task characteristics are considered specifically in relation to the technology that supports the tasks and are broken down to different levels of detail depending on the complexity of the tasks performed (Ammenwerth et al., 2006; Goodhue & Thompson, 1995).

Applying the TTF theory in different environments will result in different specific task characteristics. In literature, the process followed to identify the task characteristics are however similar and typically involve analysing the tasks performed in an environment and creating various task categories and subcategories that can be related to TTF (Ali et al., 2018; Barki et al., 2007; Goodhue, 1998; C. C. Lee & Cheng, 2007; Wang & Lin, 2019).

Technology is defined as the tools that are used by individuals to execute or assist in executing their tasks (Ammenwerth et al., 2006; Goodhue & Thompson, 1995; L. Yang et al., 2013). Similar to the discussion of task characteristics, different technologies will have different characteristics which are defined by the researcher with consideration to the environment which it is used in and the tasks it aims to support (Gebauer & Shaw, 2004).

TTF is defined as the extent to which a technology assists an individual in performing his or her tasks (Ammenwerth et al., 2006; Dishaw & Strong, 1998a; Fuller & Dennis, 2009; Goodhue & Thompson, 1995; Howard & Rose, 2018; L. Yang et al., 2013); it is consequently affected by the interaction between the characteristics of the task and the functionalities of the technology (C. C. Lee & Cheng, 2007). Typical concepts that are considered when measuring fit, as defined by Goodhue and Thompson (1995), are data quality, data locatability, authorisation to access data, data compatibility, ease of use/training, production timeliness, systems reliability and Information System relationship with users.

As noted by Fuller and Dennis (Fuller & Dennis, 2009), the fit between task and technology is a necessary but insufficient condition for achieving good performance. The technology is required to be utilised by the individual for the performance impacts to be seen. Typical concepts that are considered for utilisation include the usage duration and frequency of use.

The purpose of the study by Goodhue and Thompson (1995) was to show that a positive impact of technology requires a good fit between the task and technology characteristics. The inference is therefore made by the authors that, when technology fits the task characteristics it aims to support, and is effectively utilized, it should result in improved performance (Goodhue et al., 2000). The improved performance is typically due to the smooth execution of the task, reducing the cost of performing the task, or making the task easier to accomplish (C. C. Lee & Cheng, 2007).

4.3. Scoping review initialisation

The scoping review was selected as a suitable method to identify a tangible set of evaluation concepts from the TTF theory and to verify the selection of the theory based on the identification requirement part of the tool development requirements. The scoping review conducted in this chapter follows the methodology discussed in Section 2.4.2 and is summarised in Table 4.1 along with an indication of its implementation in the corresponding sections.

Table 4.1 Overview of the scoping review methodology and its respective implementation

Step	Corresponding sections
(1) Identify the research questions	Section 1.3
(2) Identify relevant studies	Section 4.3.1
(3) Select studies	Section 4.3.2
(4) Code the data	Section 4.3.3
(5) Collate, summarize, and report the results	Sections 4.4-4.7

The aim of the scoping review is to support answering SRQ 2, namely, *How can the application of an Information Systems theory inform a tangible set of evaluation concepts to aid the development of the interactive tool for supporting the evaluation of CBHIS?* This consequently serves as the research question for the scoping review. The completion of steps 2-5 are discussed in the following sections.

4.3.1. Search strategy

To identify relevant studies that can be used to answer the research question, a search was conducted on the Scopus research database. Scopus was chosen due to the large number of indexed journals covering a wide range of disciplines. Relevant studies were considered articles published in peer-reviewed journals that *apply* the TTF theory as part of their primary aim were considered – including studies that give synopses of work done. it was discovered in extant literature that the term *application*, in relation to TTF, is used in a broad manner extending to the use of smaller concepts, adaptations and findings. In this study, *application* (of TTF) is used in a specified manner, to consider where TTF is used as conceptualized in Section 4.2.

An exploratory search was conducted on 23 August 2019 with the terms "Task-Technology Fit" OR "technology-to-performance", resulting in 637 results. The titles and abstracts of the top ten most cited and top ten most recent articles were examined to identify relevant keywords to be included to ensure the comprehensiveness of the search. Variations of the terms evaluate, apply, diagnose, and assess were found to be closely related to the search for studies related to the *application* and consequently included in the search. The search was conducted on 04 October 2019 with the search criteria including the terms ("Task-Technology Fit" OR "technology-to-performance") AND (evaluat* OR appl* OR diagnos* OR assess*), limited to journal articles, which yielded 173 results.

Various measures were taken to ensure that all influential articles were included in the study. Bibliometrix, an R-tool for comprehensive science mapping analysis (Aria & Cuccurullo, 2017), was used to analyse the most cited articles out of the local 173 results; this led to the addition of one more article. The tool was also used to determine the top authors cited in the set of articles. A further search was done on Scopus and ResearchGate to determine whether any further important studies has been published by these authors, resulting in two articles being added. As a final measure, as full-text articles were screened, a list of the literature used by each study as theoretical foundation was compiled. All the items on the list were however already included and therefore no further studies were added.

4.3.2. Study selection

The aims set out in Section 4.1 was used to define the inclusion exclusion criteria as shown in Table 4.2. As discussed in the previous section, a large number of studies uses certain concepts of TTF without discussing or applying the theory as conceptualized in Section 4.2, the three exclusion criteria were designed to specifically eliminate these articles.

The titles and abstracts of the 176 studies were screened and 43 studies were excluded from the review based on EC 1. The online availability of the remaining 133 was checked and 5 were found to be unobtainable. The available full-text studies were downloaded, and the data of the studies was exported from Scopus into MS Excel.

Table 4.2 Inclusion and exclusion criteria applied to identify relevant studies

Inclusion Criteria		Exclusion Criteria	
IC 1	Application of the TTF	EC 1	No mention of TTF in abstract
IC 2	Thorough discussion of theory	EC 2	Isolate TTF concepts
		EC 3	TTF not central to the study

The criteria were applied to the abstracts and the full-text articles and 91 studies were excluded due to the content being irrelevant to the study, based on EC 2 and EC 3. The entire process followed in selecting relevant studies, based on the PRISMA statement for reporting systematised reviews (Moher et al., 2009), is depicted in Figure 4.2.

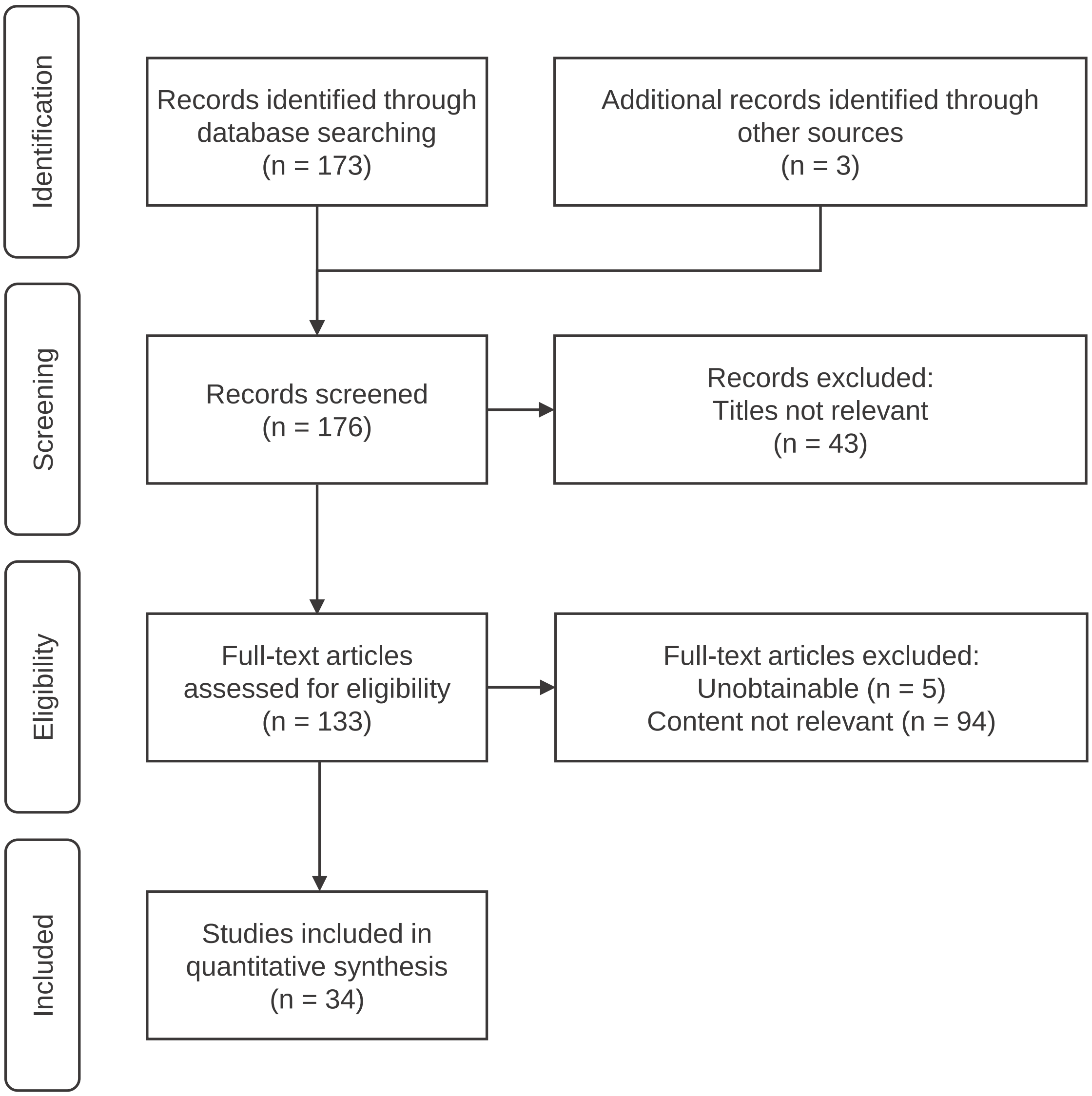


Figure 4.2 Study selection process (Moher et al., 2009)

The final set of 34 studies that met all the inclusion criteria were further analysed as discussed in the following sections.

4.3.3. Coding the data

The coding step required the articles included in the review to be re-read thoroughly with the aim of extracting data relevant to the research questions. A charting form, shown in Table 4.3, was formulated based on the research questions and the identification requirements part of the tool development requirements to ensure credibility of the data to be extracted.

Table 4.3 Scoping review charting form

Category	Identifier	Name	Description
Descriptive	D1	Author(s)	The list of authors for the study
	D2	Year of publication	The year in which the study was published
	D3	Study aims	The purpose for which the TTF theory was applied
	D4	Application environment	The environment in which the study was conducted
	D5	Assessed technology	The type of technology that was assessed in the study
Conceptual	C1	Specific concepts	The set of evaluation concepts which emerge from the analysis of each TTF component
	C2	Key findings	Summary of the studies' findings in applying the TTF theory or, specifically, its four components

The full-text articles were imported into ATLAS.ti software which was used for qualitative data analysis, and the charting form was used to define the categories for the coding process. The full-text studies were then read-through and coded as applicable. The coded data was exported to MS Excel for a deeper analysis consisting of a 1) descriptive and 2) conceptual analysis of the data. These two parts are discussed in the following sections.

4.4. Descriptive data analysis

The first part of the data analysis aimed to provide an overview of the literature included in this study to verify the selection of the TTF theory based on the identification requirements part of the tool development requirements. In this section, the analysis of the data is discussed. The synthesis of this analysis to verify the selection of the theory is discussed in Section 4.8.

The timeline of the number of publications is depicted in Figure 4.3. The first study, which was published in 1995, is the seminal article which proposed the TTF theory (Goodhue & Thompson, 1995). The timeline shows the continued research interest in the TTF theory over the years. In 2012, Furneaux (2012, p. 88) identified the *notable increase in the use of TTF theory* which is verified in Figure 4.3 and shows the continuation of this trend post-2012.

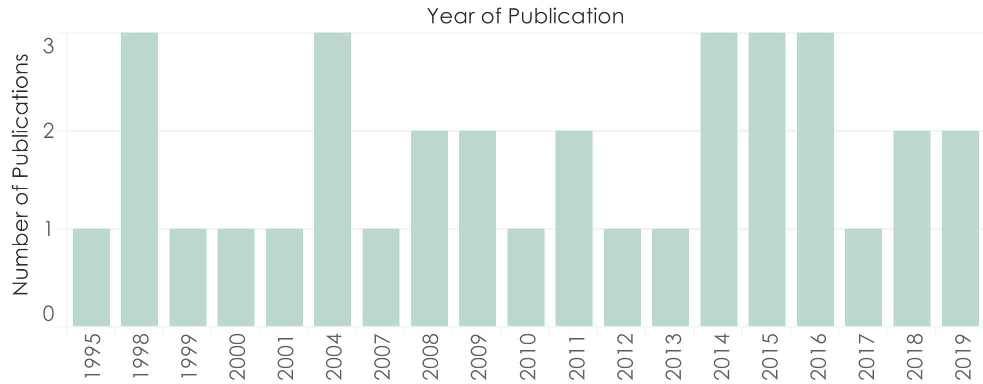


Figure 4.3 Timeline of publications

The different studies were grouped together based on their purposes for applying the TTF theory, and different levels of categories were defined, as depicted in Figure 4.4. The first high-level category was defined as studies that apply TTF with the primary aim of generating theory, termed *Generate Theory*. The theory generated was found to be primarily concerned with defining or refining the measurements used for the TTF components (Gebauer & Shaw, 2004; Goodhue, 1998; Goodhue et al., 2000) or the TTF model (Dishaw & Strong, 1998b; Gebauer & Tang, 2008; Goodhue & Thompson, 1995; Howard & Rose, 2018; Liu et al., 2011; H. D. Yang et al., 2013); summarizing existing studies (Cane & McCarthy, 2009); testing the components and/or relationships of the TTF model (Staples & Seddon, 2005; Zigurs et al., 1999).

The second high-level category was defined as studies that apply TTF in order to assess certain real-world phenomena; this was termed *Assess Phenomena*. These applications were concerned with two major aspects – the components, such as the technology characteristics, that are antecedents to TTF (Ali et al., 2018; Gebauer & Ginsburg, 2009; Hsiao & Chen, 2012; Melchor-Ferrer & Buendía-Carrillo, 2014; Pelzer et al., 2015; Rivera et al., 2016) and the assessing effects of TTF. These studies concerned with assessing the effects were further broken down into those that assess the impact or benefit of TTF (Bere, 2018; Cady & Finkelstein, 2014; P. Chen et al., 2015; Glowalla & Sunyaev, 2014; Ioimo & Aronson, 2004; D.-Y. Kim et al., 2018; Lepanto et al., 2011; McGill & Klobas, 2009; Raven et al., 2010; Tam & Oliveira, 2016; Yi et al., 2016) and those that assess factors relating to the use of, or intention to use, the technology based on TTF (Chang, 2008; Dishaw & Strong, 1998a; Huang et al., 2017; C. C. Lee & Cheng, 2007; Pendharkar et al., 2001; Sheehan et al., 2012; Vongjaturapat, 2018; Wang & Lin, 2019).

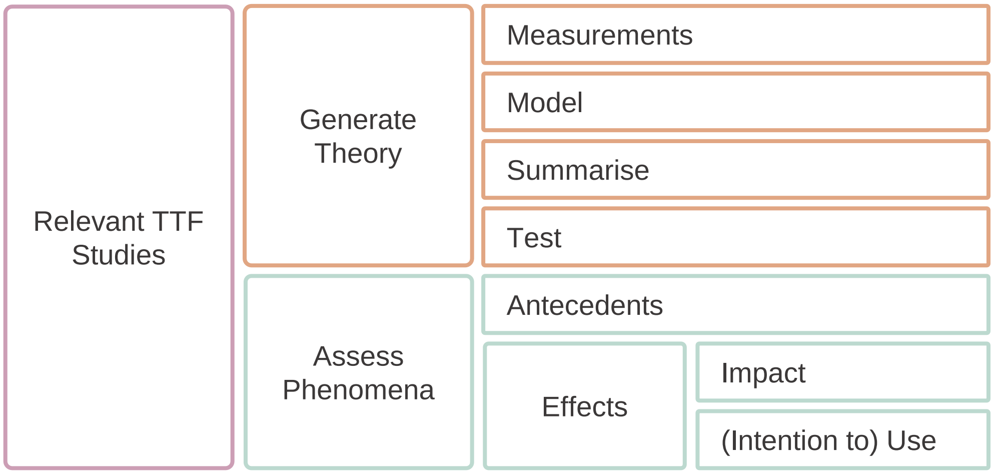


Figure 4.4 Categorisation of relevant TTF studies

The two high-level categories, *Generate Theory* and *Assess Phenomena* were used to determine the trends in the type of studies published over time. The cumulative number of studies published for the two highest-level categories was calculated over time and depicted in Figure 4.5. It can be seen that a larger number of studies that aimed to generate theory were initially published and as time progressed the focus shifted to the application of TTF to assess phenomena.

As the theory gained recognition, different features were refined and the impact of applying the theory for assessing different phenomena was recognized. The focus of studies is expected to shift from predominantly theory-based to applying it, as seen in the increasing trend depicted in Figure 4.5 – which reveals that eventually, praxis side of the theory is exponentially overtaking the theoretical

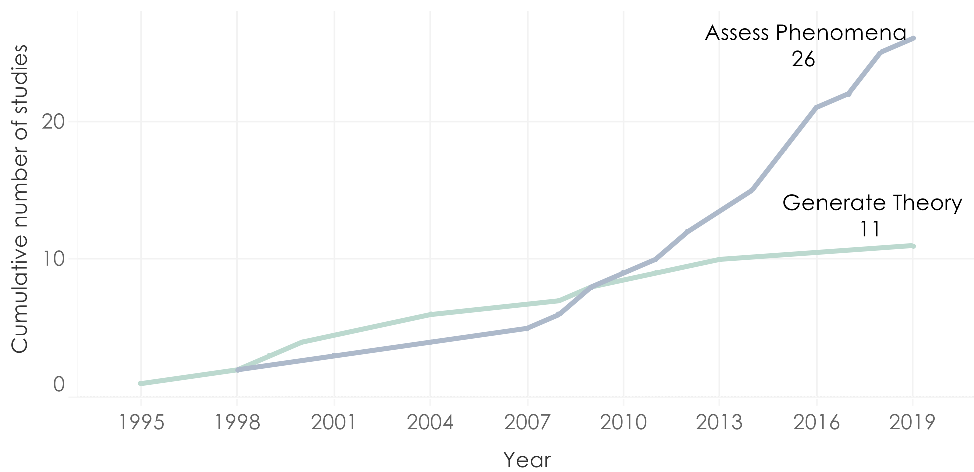


Figure 4.5 Cumulative number of studies over time

The assessment of TTF antecedents was only introduced in 2009, 11 years after the first application of the theory to assess the impact/benefit, and it's still an emerging area of research which holds considerable potential. Since the antecedents have an effect on TTF, applying the theory to assess these factors has proven to be beneficial in identifying improvements that can be made to TTF.

The different studies were further classified using the Global Industry Classification Standard developed by S&P Dow Jones Indices, an international financial data and investment services company, and MSCI, a provider of global indices and benchmark-related products and services (S&P Dow Jones Indices & MSCI, 2018). The classification standard is structured into four categories: sector; industry group; industry; and sub-industry. A sub-industry overview of the studies included in the scoping review is depicted in Figure 4.6. Two of the studies (Goodhue et al., 2000; Liu et al., 2011) were conducted as experiments in a controlled environment and therefore categorised as *Experimental* to supplement the existing categories.

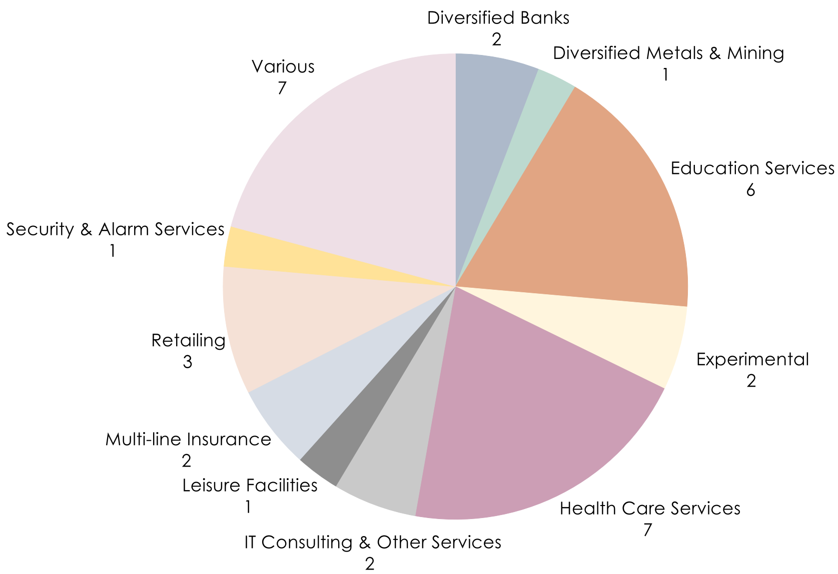


Figure 4.6 Divisions of TTF application environments

Most of the studies were applied in either a *Health Care Services* environment or in various, different, but not explicitly identified, environments. Although the tasks performed in these different environments will vary greatly, the wide range of application environments provides evidence that the TTF has been applied in diverse settings. Furthermore, the diverse environments create the opportunity for interesting future research to be done on the similarities and differences in the way in which TTF is applied.

The final component of the descriptive analysis was to identify and categorise the technology used in each of the relevant studies and is summarised in Figure 4.7.

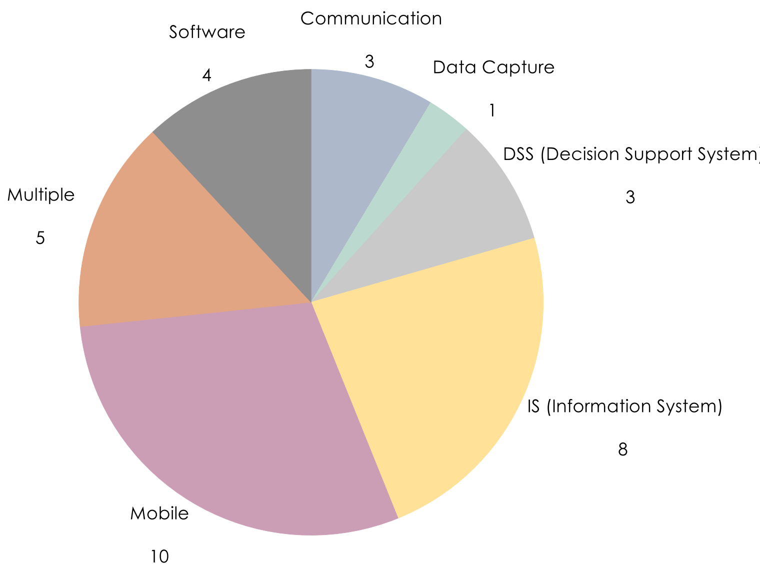


Figure 4.7 Divisions of the technology assessed in the relevant studies

Since the TTF theory is mainly part of IS research, it was expected that the application of TTF would be primarily concerned with IS. An interesting observation was the growing research interest in mobile technology. The first two relevant studies applying TTF to mobile technology (Gebauer & Shaw, 2004; Ioimo & Aronson, 2004) were published in 2004 after which the majority of published articles included in this study (40.7%) were focused on mobile technology. This finding makes sense in considering the rapid uptake, improved capabilities, and gradual dependence on smartphone technology since 2004.

Having overviewed the selected literature, the second part of the data analysis was completed to identify the set of evaluation concepts and is discussed in the following section.

4.5. Identification of the evaluation concepts

The second part of the analysis aimed to identify specific evaluation concepts from the included studies' discussion of the TTF components and how these were applied. The evaluation concepts identified are discussed in the following sections based on the TTF component in which they were identified. This discussion is used to verify the selection of the TTF theory (Section 4.8) and catalogue the concepts into an inventory to answer SRQ 2 (Section 4.9).

4.5.1. Task-Technology Fit concepts

Melchor-Ferrer and Buendía-Carrillo (2014) make the important observation that TTF concepts have been defined, modified and supplemented in various ways to suit the purposes of the intended studies. In the literature, it was found that researchers classify different concepts on different levels. Where some classify one concept as a measure, others classify it as a dimension of TTF. For example, where certain studies consider information currency as a measure of data quality, others consider data quality and information currency as two separate measures.

A flexible approach was taken in the identification of concepts to ensure a broad, comprehensive inventory. All concepts identified in the studies, irrespective of what the researchers defined them as, were added to the inventory, as summarised in Table 4.4.

Table 4.4 Task-Technology Fit concepts identified in literature

Concept identified	Description	References
Ability to carry out tasks	Whether the technology enables the user to execute their tasks.	(Furneaux, 2012; Melchor-Ferrer & Buendía-Carrillo, 2014)
Accessibility	Ease of accessing required information.	(Bere, 2018; P. Chen et al., 2015; Dishaw & Strong, 1998a; Goodhue, 1998; Melchor-Ferrer & Buendía-Carrillo, 2014; Yi et al., 2016)
Assistance	Ease of getting help on when problems or difficulties are encountered.	(Chang, 2008; Goodhue, 1998)
Authorisation	User has the authorisation to access all the information that would be relevant in performing tasks.	(Goodhue & Thompson, 1995; C. C. Lee & Cheng, 2007)
Compatibility	Information from different sources are easily consolidated without problems.	(Dishaw & Strong, 1998a; Goodhue & Thompson, 1995; Ioimo & Aronson, 2004; C. C. Lee & Cheng, 2007; McGill & Klobas, 2009; Staples & Seddon, 2005)

Concept identified	Description	References
Confusion	Information presented in a manner that makes it difficult to differentiate between different aspects thereof.	(P. Chen et al., 2015; Goodhue, 1998)
Consulting	Availability of consulting services received from the technology.	(Goodhue & Thompson, 1995; Ioimo & Aronson, 2004; C. C. Lee & Cheng, 2007)
Contextual data quality	Data's fitness for intended use.	(Chang, 2008; Glowalla & Sunyaev, 2014; Goodhue & Thompson, 1995; C. C. Lee & Cheng, 2007; Melchor-Ferrer & Buendía-Carrillo, 2014)
Currency	The information displayed is current enough to carry out tasks and presented in the required time.	(P. Chen et al., 2015; Dishaw & Strong, 1998a; Goodhue, 1998; Goodhue & Thompson, 1995; Huang et al., 2017; C. C. Lee & Cheng, 2007; Lepanto et al., 2011; McGill & Klobas, 2009; Staples & Seddon, 2005)
Ease of use	Ease of doing what is required.	(Chang, 2008; P. Chen et al., 2015; Dishaw & Strong, 1998a; Goodhue, 1998; Goodhue & Thompson, 1995; Huang et al., 2017; Ioimo & Aronson, 2004; C. C. Lee & Cheng, 2007; Lepanto et al., 2011; McGill & Klobas, 2009; Melchor-Ferrer & Buendía-Carrillo, 2014; Raven et al., 2010; Staples & Seddon, 2005; Wang & Lin, 2019)
Familiarity	Acquaintance with the technology.	(Chang, 2008)
Flexibility	Ability to make changes to the technology base on personal preference.	(Melchor-Ferrer & Buendía-Carrillo, 2014)
Locatability	Ease of finding required information.	(Dishaw & Strong, 1998a; Goodhue, 1998; Goodhue & Thompson, 1995; Ioimo & Aronson, 2004; C. C. Lee & Cheng, 2007; Lepanto et al., 2011)
Meaning	Ease of understanding what different aspects of the information means.	(P. Chen et al., 2015; Dishaw & Strong, 1998a; Goodhue & Thompson, 1995; C. C. Lee & Cheng, 2007)
Preference	Conceptualised in terms of the preference between a set of alternative technologies.	(Gebauer & Shaw, 2004)
Presentation	Information is presented in a useful manner.	(P. Chen et al., 2015; Dishaw & Strong, 1998a; Goodhue, 1998; McGill & Klobas, 2009)
Production timeliness	Information Systems is able to adhere to production schedule.	(Bere, 2018; Chang, 2008; Goodhue & Thompson, 1995; C. C. Lee & Cheng, 2007; Lepanto et al., 2011; Melchor-Ferrer & Buendía-Carrillo, 2014)

Concept identified	Description	References
Reliability	Whether the user displays confidence in the information presented by the technology.	(Lepanto et al., 2011)
Responsiveness	Time taken to respond to requests made by the user for assistance, changes, or services.	(Chang, 2008; Goodhue & Thompson, 1995; Ioimo & Aronson, 2004; C. C. Lee & Cheng, 2007)
Right data	The information presented for the tasks that need to be performed is correct.	(Chang, 2008; P. Chen et al., 2015; Dishaw & Strong, 1998a; Goodhue, 1998; Goodhue & Thompson, 1995; Huang et al., 2017; C. C. Lee & Cheng, 2007; Lepanto et al., 2011; McGill & Klobas, 2009; Staples & Seddon, 2005; Yi et al., 2016)
Right level of detail	The information is displayed at a sufficient level of detail.	(Dishaw & Strong, 1998a; Goodhue & Thompson, 1995; Huang et al., 2017; Ioimo & Aronson, 2004; C. C. Lee & Cheng, 2007; Lepanto et al., 2011; McGill & Klobas, 2009; Staples & Seddon, 2005; Yi et al., 2016)
Satisfaction	Meet or exceed the expectations that the user has of the technology.	(S. K. Kim et al., 2013; Pendharkar et al., 2001)
Specific to task	Conceptual match between the task and technology characteristics.	(Dishaw & Strong, 1998b; Liu et al., 2011; Pendharkar et al., 2001; Sheehan et al., 2012)
Synchronisation	Information exchange between systems takes place frequently enough for effective decision making.	(P. Chen et al., 2015)
Systems reliability	Dependability and consistency of system up time.	(Chang, 2008; P. Chen et al., 2015; Dishaw & Strong, 1998a; Goodhue, 1998; Goodhue & Thompson, 1995; Huang et al., 2017; C. C. Lee & Cheng, 2007)
Tech Interest and Dedication	Extent to which IS takes business problems seriously.	(Goodhue & Thompson, 1995; Ioimo & Aronson, 2004; C. C. Lee & Cheng, 2007)
Tech performance	Extent to which the IS meets the service level agreements.	(Goodhue & Thompson, 1995; C. C. Lee & Cheng, 2007)
Tech understanding of business	Extent to which IS understands the organisation's objectives/mission.	(Goodhue & Thompson, 1995; C. C. Lee & Cheng, 2007)
Training	Availability of training when required.	(Goodhue & Thompson, 1995; C. C. Lee & Cheng, 2007; McGill & Klobas, 2009; Raven et al., 2010; Staples & Seddon, 2005)

The concepts described in Table 4.4 were all applied in the respective literature to make certain value judgements about the extent to which the technology assists individuals to perform their tasks. These concepts therefore provide an important set of considerations or areas of evaluation for the development of the interactive tool. At this stage of the research, the focus was to simply identify the concepts that emerge; the necessary refinement of these concepts is further explored in the following chapters.

4.5.2. Task characteristics

Goodhue and Thompson (1995) introduced the task characteristics concept as attributes of tasks that result in an individual being reliant on the technology. In the rest of the analysed literature, the conceptualisation of task characteristics was found to be ambiguous. The three high-level trends of its usage are summarised in Figure 4.8.

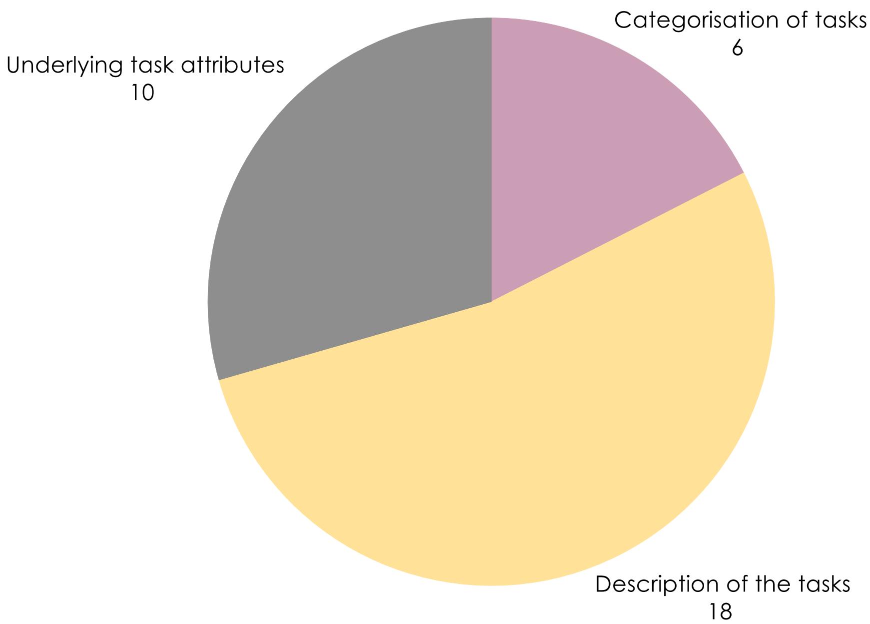


Figure 4.8 Trends in the application of task characteristics

A number of studies considered the underlying attributes of the task (Bere, 2018; Gebauer & Shaw, 2004; Gebauer & Tang, 2008; Goodhue, 1998; Huang et al., 2017; S. K. Kim et al., 2013; Liu et al., 2011; Pelzer et al., 2015; Tam & Oliveira, 2016; Zigurs & Buckland, 1998) as suggested by Goodhue and Thompson (1995). The concepts that emerged from the detailed analysis of each study is summarised in Table 4.5. The concepts are not a comprehensive set of attributes but do provide important considerations when analysing the tasks.

Table 4.5 Underlying task attribute concepts

Concept identified	Description	References
Complexity	The extent of complication inherent in a task.	(Melchor-Ferrer & Buendía-Carrillo, 2014; Zigurs et al., 1999)
Difficulty	The need for particular skills or much effort to accomplish a task.	(Huang et al., 2017)
Frequency	The rate at which a task is repeatedly performed.	(Gebauer & Shaw, 2004)
Immediacy	The need to suddenly perform a task without delay.	(Bere, 2018; Gebauer & Shaw, 2004; Gebauer & Tang, 2008; Ioimo & Aronson, 2004; S. K. Kim et al., 2013)

Interdependence	The extent to which a task both depends on other tasks and has other tasks depending on it.	(Gebauer & Tang, 2008; Goodhue, 1998; Goodhue & Thompson, 1995; S. K. Kim et al., 2013; Tam & Oliveira, 2016)
Mobility	The extent to which the task can be performed without being limited to a particular setting.	(Gebauer & Shaw, 2004; S. K. Kim et al., 2013)
Non-routineness	The extent to which a task does not follow a regular procedure.	(Gebauer & Tang, 2008; Glowalla & Sunyaev, 2014; Goodhue & Thompson, 1995; Pendharkar et al., 2001; Tam & Oliveira, 2016)
Structuredness	The extent to which a task is clearly defined, able to be executed without requiring judgement.	(Gebauer & Shaw, 2004; Liu et al., 2011)

The description of non-standard task characteristics based on the application environment may explain why the majority of studies, twenty-four out of thirty-four, did not consider underlying tasks attributes. Eighteen of the studies (Ali et al., 2018; Cane & McCarthy, 2009; P. Chen et al., 2015; Dishaw & Strong, 1998a; Goodhue et al., 2000; Hsiao & Chen, 2012; C. C. Lee & Cheng, 2007; Lepanto et al., 2011; McGill & Klobas, 2009; Raven et al., 2010; Rivera et al., 2016; Staples & Seddon, 2005; Wang & Lin, 2019; Yi et al., 2016) provided a description of the tasks at varying levels of detail.

The six remaining studies (Cady & Finkelstein, 2014; Dishaw & Strong, 1998b; Howard & Rose, 2018; Melchor-Ferrer & Buendía-Carrillo, 2014; Pelzer et al., 2015; H. D. Yang et al., 2013) developed task categories based on their explicit or implicit similarities. This approach was found to be valuable in that it allows the analysis of numerous tasks in one instance, rather than having to analyse each individually.

Irrespective of the conceptualisation of task characteristics, it was found that the common perspective throughout all of the studies was to describe it in a manner, and level of detail that allowed for the respective studies' research questions to be answered. The set of concepts described in Table 4.5 provide important considerations which may contribute to or influence 1) the criticality of the technology's fitness, 2) the user's evaluation of the technology, and 3) the ease/difficulty in achieving fit. These considerations are all important in the development of the interactive tool and all of the concepts identified are included in the inventory, which is further refined in the following chapters.

4.5.3. Technology characteristics

As stated in Section 4.2, technology refers to the tools that are used by individuals to carry out their tasks. Goodhue and Thompson (1995) refer to the technology characteristics as the underlying qualities of the technology that is used. Similar to task characteristics, the analysis of the literature revealed that no standard conceptualisations or approaches exist in the definition or application of technology characteristics. The trends in how technology characteristics were applied in the literature are summarised in Figure 4.9.

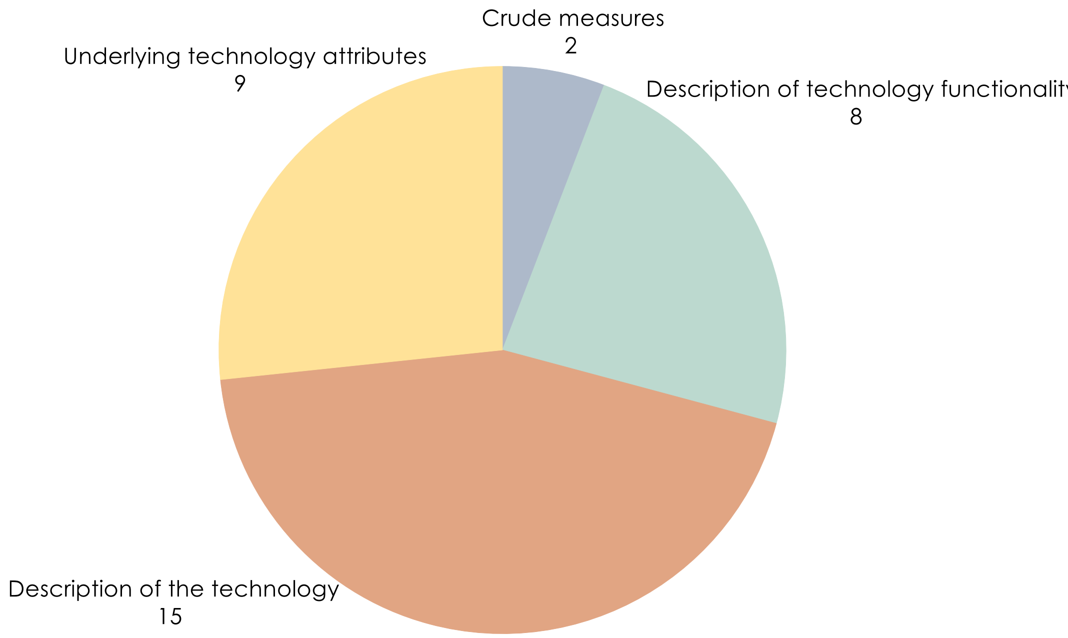


Figure 4.9 Trends in the application of technology characteristics

The majority of the studies (Ali et al., 2018; Cady & Finkelstein, 2014; Cane & McCarthy, 2009; Chang, 2008; Dishaw & Strong, 1998a; Goodhue et al., 2000; Howard & Rose, 2018; Hsiao & Chen, 2012; Lepanto et al., 2011; McGill & Klobas, 2009; Melchor-Ferrer & Buendía-Carrillo, 2014; Pendharkar et al., 2001; Raven et al., 2010; Staples & Seddon, 2005; Yi et al., 2016) do not go into any detail regarding the actual technology characteristics but simply identify the technology, such as saying that it is a procurement management system. This indicates that the range of the fitness concepts (Section 4.5.1) sufficiently incorporates aspects of the technology that are relevant for theory application within the respective studies.

A number of studies (Bere, 2018; Gebauer & Shaw, 2004; Gebauer & Tang, 2008; Glowalla & Sunyaev, 2014; Huang et al., 2017; S. K. Kim et al., 2013; Liu et al., 2011; Pelzer et al., 2015; Rivera et al., 2016) did however consider additional underlying technology characteristics. The different concepts that emerged within these studies are summarised in Table 4.6.

Table 4.6 Underlying technology characteristic concepts

Concept identified	Description	References
Adaptivity	The extent to which the technology can be modified for alternative use.	(Huang et al., 2017)
Autonomy	The extent to which the technology can execute tasks without direct human initiation.	(S. K. Kim et al., 2013)
Communication	The ability of the technology to enable communication.	(Gebauer & Tang, 2008; Pelzer et al., 2015)
Non-functional attributes	Components of the technology which contribute indirectly to the usage (such as processing power).	(Bere, 2018; Gebauer & Shaw, 2004; Glowalla & Sunyaev, 2014; S. K. Kim et al., 2013; Rivera et al., 2016)

Concept identified	Description	References
Portability	The extent to which the technology can be carried around and used in different environments.	(Bere, 2018; Gebauer & Shaw, 2004; Huang et al., 2017)
Rationality	The extent to which the technology provides data-based support for decision making.	(Liu et al., 2011)
User support	The extent to which assistance is available for users of the technology.	(Gebauer & Shaw, 2004)

Although the concepts summarised in Table 4.6 are more specific to the technology being observed within the examined studies, certain concepts may also be of relevance to be investigated as part of the interactive tool developed in this study. All the concepts are therefore added to the inventory and the refinement thereof are also explored in the following chapters.

4.5.4. Utilisation

As stated in Section 4.2, even if a perfect TTF is achieved, the technology needs to be utilised before it results in performance impacts. Similar to the other TTF theory components, utilisation is conceptualised and analysed in multiple ways, depending on the objectives of the study. The different concepts which emerged from this scoping review is summarised in Table 4.7.

Table 4.7 Utilisation concepts

Concept identified	Description	References
Choice	Whether an individual chooses to use the technology or not.	(Tam & Oliveira, 2016; Yi et al., 2016)
Duration	The length of time that the technology is used per instance.	(Dishaw & Strong, 1998b; McGill & Klobas, 2009; Staples & Seddon, 2005; H. D. Yang et al., 2013)
Frequency	How often the technology is used in a specified period.	(Gebauer & Shaw, 2004; Howard & Rose, 2018; S. K. Kim et al., 2013; Lepanto et al., 2011; McGill et al., 2011; McGill & Klobas, 2009; Staples & Seddon, 2005; H. D. Yang et al., 2013)
Intention to use	The user's opinion on whether there is an intention to use the technology.	(Ammenwerth et al., 2006; Chang, 2008; Raven et al., 2010; Wang & Lin, 2019)
Perceived dependence	The user's attitude towards the extent of dependence on the technology.	(Goodhue & Thompson, 1995; H. D. Yang et al., 2013)
Usage proportion	A calculated value of the number of times the technology is used to perform a task over the total number of times a task is performed.	(Dishaw & Strong, 1998b; Gebauer & Shaw, 2004; Goodhue & Thompson, 1995)

A number of studies (Goodhue & Thompson, 1995; Staples & Seddon, 2005; Yi et al., 2016) further consider the antecedents of utilisation; they examine certain elements that play a role in whether or not, and to what extent, technology is utilised. These antecedents are grounded in various theories of attitude and behaviour and include elements such as expected consequences, incentive to use, social norms and habits. These antecedents are however outside the scope of this study.

In most modern environments, including the environment which forms this study's context, technology is no longer an addition or supplementary tool; rather, it is completely embedded in the operations in an organisation and is mandatory for use. In these environments, Staples and Seddon (2005) suggest that the attitude and behavioural concepts, such as *intention to use*, may provide valuable insights with practical implications.

Similar to concepts identified in Sections 4.5.1-4.5.4, all of the utilisation related concepts summarised in Table 4.7 are catalogued in the inventory (Section 4.9) and further refined in the following chapters.

4.6. Critical reflections

In the analysis of the various studies examined, a number of limitations were identified. Firstly, the various studies identified in Section 4.4 that assess phenomena followed a similar high-level methodology to apply the theory but exhibited variance in the exact execution thereof. In the methodology section of these articles, the methodology is consistently discussed but follow the logical flow of the TTF model and not a standardised, referenced methodology or application guidelines. This presents challenges in judging the rigour of the TTF application in these studies as well as the greater research effort when wanting to apply the theory.

Secondly, these studies that assess phenomena all used surveys, questionnaires, or interviews for data collection, and statistical analyses were conducted to make judgements about the phenomena under investigation. All of these methods rely on the subjective opinion of the participants even though certain concepts such as the *frequency of usage* or even the *currency of information* may be measured, or at least compared, in an objective manner.

Thirdly, in all the studies reviewed there is a fundamental underlying assumption that the technology is used correctly when utilised. If technology is used incorrectly it will likely not result in the performance impact anticipated by the TTF model. It was however found that none of the studies in this scoping review identify or discuss this important assumption. There is therefore a need to formulate further concepts that either incorporate the investigation of correct usage of the technology alongside, or as part of, utilisation.

Fourthly, the TTF model suggests and tests relationships between the various TTF components. The specific concepts identified and discussed in Section 4.5, which comprise these components, are however considered independently. None of the studies included in this review considered the nature or effect of relationships between concepts.

Finally, the findings from most of the studies discuss the state of the phenomena under investigation and appropriateness of the TTF theory without discussions of practical implications for managerial decision making about what to do with the findings. Only one study (P. Chen et al., 2015) discussed the application of the theory in a larger context which resulted in specific decisions to be made to improve the technology. The consensus in the studies reviewed is that the theory is useful but an opportunity exists to extend the utility to inform decision making.

4.7. Review limitations

The results of the scoping review are dependent on the studies included for analysis. The initial search for relevant articles is limited in that only one database was used to search for relevant articles. This may have resulted in further relevant works being excluded from this study. Various measures were however taken to ensure that all influential studies potentially missed in the search were eventually included in this study (Section 4.3.1).

Although the intention was to define screening criteria in a manner that would ensure reliability and replicability of the screening process, the researcher acknowledges that the actual selection may be biased. This limitation is however mitigated by basing the research design on the DSR Framework (Section 2.3). The further design cycles, which are discussed in the following chapters, ensure that concepts are sufficiently refined and supplemented to compensate for any probable limitations in the case of unintentional selection bias.

4.8. Selection of the Task-Technology Fit theory

In the previous chapter, the insights obtained from the M&E review were used to formulate identification requirements to support the identification of a tangible set of evaluation concepts from the IS domain by guiding the selection of an appropriate IS theory. In this chapter, an in-depth review was conducted on the TTF theory, which is suggested for selection in this study. The relevant set of requirements formulated in Section 3.4 is presented in Table 4.8 along with a description of the appropriateness of the TTF theory for selection.

Table 4.8 Appropriateness of the TTF theory based on the tool development requirements

Tool development requirement	Appropriateness of the TTF theory
IR1 – The theory should align with the overall emphasis of this study.	Conceptually, the TTF theory suggests that performance impacts require the technology to fit the tasks that need to be performed by individual users, and that the technology should be properly utilised (Section 4.2). These aspects of the theory align with the set of problems identified in this study's problem statement (Section 1.2) which identified problems related to the system (fitness), its correct usage and utilisation.
IR2 – The theory should be widely accepted within the IS domain and applied regularly since its proposal.	Furneaux (2012, p. 102) identifies TTF as "an important theory that is strongly rooted within the field of Information Systems". The discussions in Section 4.4 reveal the large number of publications related to the theory as well as the increasing interest and application thereof since its proposal in 1995. The review discussed in this chapter considered 34 studies which directly applied the TTF model, with roughly 40% of the studies published in the last five years of when the review was conducted.

Tool development requirement	Appropriateness of the TTF theory
IR3 – The theory should have been applied across a wide range of systems.	The theory has been applied across a wide range of environments (see Figure 4.6), including health care services, education, and retailing. The theory has also been applied to numerous types of technology (see Figure 4.7), including mobile technology, IS, and software.
IR4 – The theory should contribute sufficient explanatory power which may be checked by the nature of the concepts	The discussion of the individual concepts identified in Section 4.5 reveal a large and diverse number of concepts which reveal definite potential for explanatory application which can be exploited through the successive design cycles.

As shown in Table 4.8, the TTF theory meets the tool development requirements and is therefore selected in this study. The review conducted in this chapter is synthesised in the following section and the individual evaluation concepts are catalogued as a theoretical concept inventory for the development of the interactive tool is discussed.

4.9. Presentation of the evaluation concept inventory

The evaluation concept inventory provides a tangible set of evaluation concepts for further development of the interactive tool, thereby answering SRQ 2. The evaluation concepts identified in Section 4.5 were given unique identifiers based on the origin of the evaluation concepts. The identifiers of the concepts included as part of the TTF concepts are denoted with the prefix *TTF-;* Task Characteristics as *TaC-;* Technology Characteristics as *TeC-;* and Utilisation concepts as *U-.* The inventory is summarised and the complete inventory is found in APPENDIX B.

In the formulation of the evaluation concept inventory, it was discovered that the concepts are described at a very high-level. Each concept contains numerous intricacies which may be explored in great detail and, in some cases, is a research focus in itself. An example of such is the concept, *Intention to use* which was identified as a utilisation concept. Research on such a concept may for example draw from technology adoption and user acceptance studies in the field of Behavioural Sciences or factors from user-experience related to human-computer interaction studies.

Acknowledging the research depth that each individual concept contains, the higher-level descriptions provide a sufficient practical foundation for the development of the interactive tool and its subsequent application. In accordance with the DSRM, the further development and refinement of the interactive tool through iterative relevance and rigour cycles allows for the concepts to be sufficiently refined and supplemented to achieve the study objectives.

The concepts identified in each of the four major components of the TTF theory provide a range of considerations for further development of the interactive tool. The TTF concepts, depicted in Figure 4.10, are used in the studies analysed to describe the fitness of technology. This provides an important set of considerations, or areas of evaluation which can be incorporated in the interactive tool.

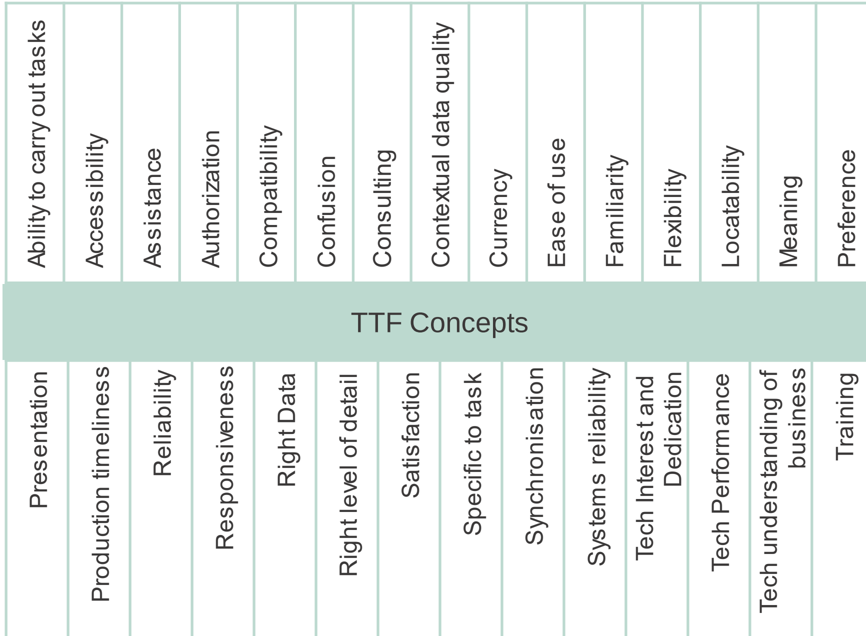


Figure 4.10 TTF concepts identified in the review

Although the concepts associated with the task characteristics are unsuited to directly describe aspects of CBHIS, these do provide important considerations which may contribute to or influence: 1) the criticality of the technology's fitness, 2) the user's evaluation of the technology, and 3) the ease/difficulty in achieving fit. These concepts, depicted in Figure 4.11, are therefore added to the inventory as they hold the potential to enhance the other concepts in the inventory by providing additional evaluation considerations.

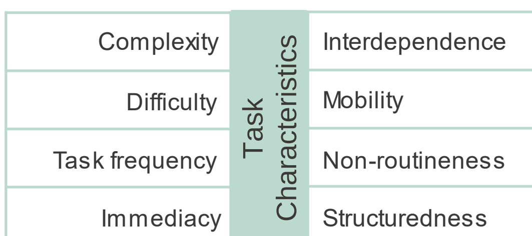


Figure 4.11 Task characteristic concepts identified in the review

Where the TTF concepts collectively consider without creating a distinction between the user, task, technology and the use environment, the technology characteristics focus on intrinsic technology characteristics detached from the former mentioned aspects. These concepts depicted in Figure 4.12, hold the potential to aid the evaluation by providing a set of considerations about the technology.

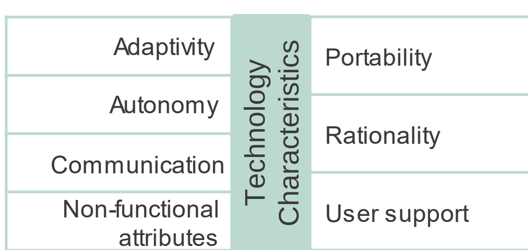


Figure 4.12 Technology characteristic concepts identified in the review

Finally, the concepts associated with utilisation are added to the evaluation concept inventory as these provide a set of considerations for the evaluation of CBHIS usage. It was found that the concepts are limited since they do not consider whether the technology is used correctly. In the refinement of the evaluation concept inventory and development of the interactive tool, further concepts need to be formulated that aid the evaluation of whether a CBHIS is not only used but used correctly.

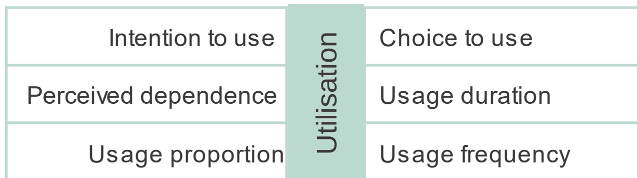


Figure 4.13 Utilisation concepts identified in the review

Having identified and catalogued the evaluation concepts, the following section concludes this chapter.

4.10. Concluding remarks: Chapter 4

In this chapter, SRQ 2[3] is answered through the completion of the second design cycle iteration depicted in Figure 4.14. This entailed conducting a scoping review to identify and catalogue a tangible set of evaluation concepts into an evaluation concept inventory. The concepts were identified from analysis of multiple studies that applied the TTF theory, a prominent theory in the IS domain, to different technologies, tasks, and environments. The identification of evaluation concepts from the domain contributes to the rigour of the evaluation concept inventory.

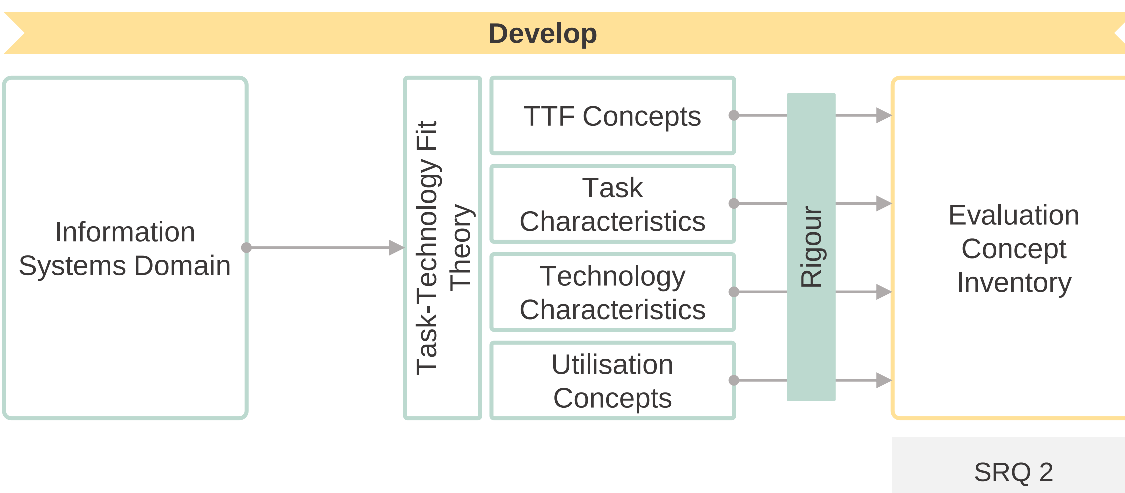


Figure 4.14 Completion of the second design cycle iteration

The evaluation concept inventory provides the conceptual basis from which the interactive tool may be further developed but it requires the relevance of evaluation concepts to CBHIS. The relevance of the concepts is evaluated as part of the two successive design cycle iterations. The findings of these evaluations are used to refine, supplement and contextualise the evaluation concept inventory, as documented in Chapter 5 and

[3] SRQ 2: How can the application of an Information Systems theory inform a tangible set of evaluation concepts to aid the development of the interactive tool for supporting the evaluation of CBHIS?

Chapter 6. Further development of the tool based on the evaluation concept inventory is also pursued in the successive design cycle iterations as documented in Chapter 5-Chapter 8.

In the following chapter, the completion of the third design cycle iteration is discussed.

Chapter 5. Theoretical case study

5.1. Introduction

In Chapter 4, a wide range of evaluation concepts were identified through a systematised review of the application of the TTF theory in literature and was catalogued into the evaluation concept inventory. In this chapter, the completion of the third design cycle iteration is discussed; it aimed to:

1. Determine the relevance and applicability of the evaluation concepts to the application environment;
2. Refine and contextualise the evaluation concepts to the application environment;
3. Identify additional evaluation concepts relevant to the application environment; and
4. Suggest relationships between the set of evaluation concepts.

These aims are achieved by conducting a theoretical case study. This approach was selected as it allows for the evaluation concept inventory to be investigated within its direct application environment, namely the evaluation of CBHIS, and thereby achieve the former aims. The case study follows the methodology discussed in Chapter 2, specifically to define the objectives (the aims described in this section); identify an appropriate case and resources (Section 5.2); analyse the resources (Section 5.3); and leverage the findings (Sections 5.4-5.5).

5.2. Identification of appropriate case and resources

In the search and identification of relevant cases, two inclusion criteria were established. Firstly, the case required the focus on an evaluation of a South African CBHIS so that the findings are relevant to the study. Secondly, it is necessary that sufficient resources concerned with the evaluation of the CBHIS are publicly available.

The case selected for analysis is the Stock Visibility System, a stock management CBHIS. In 2013, the National Department of Health partnered with private companies to find a solution for the problem they face regarding problems with medicine availability at PHC facilities. Mezzanine, a subsidiary company of Vodacom, developed the Stock Visibility System, a mobile-based application to improve stock management in PHC facilities by replacing their paper-based reporting processes with a digital method of stock control. The Stock Visibility System has since been deployed in over 3000 PHC facilities and used on multiple levels within the health system for decision making (Chowles, 2016; Viljoen & Ngumi, 2018).

A number of publicly available resources were identified for the Stock Visibility System (Chowles, 2016; Govender et al., 2018; *Stock Visibility System Standard Operating Procedure*, 2017; Viljoen & Ngumi, 2018) which included detailed evaluations on the technology. These publications were found to contain sufficient information which could be further analysed as part of the fourth stage of the methodology, discussed in the following sections.

5.3. Analysis of case study resources

Having identified the relevant resources, the analysis of these resources was done to achieve the aims set out in Section 5.1 and is discussed in this section.

The data analysis process discussed in Chapter 2 was used to guide the analysis of the case study data. The resources were thoroughly read to understand the purpose, usage, and context of the technologies. From the data set, two documents were selected (Govender et al., 2018; Viljoen & Ngumi, 2018) to be further analysed. Both of the selected documents were concerned with discussing different aspects of the CBHIS relevant to evaluation.

ATLAS.ti, the qualitative data analysis software used in the scoping review (Section 4.3.3), was used for data analysis. The two selected documents were imported into the software and individual codes were generated for each of the concepts in the evaluation concept inventory. The text was analysed and coded using the evaluation concept inventory descriptions to guide the selection of relevant codes. In the case that a concept emerged from the case study that could not be immediately related to any of the existing concepts, the concept would be coded as "other" for later review.

The coded data was then exported to MS Excel and unique identifiers were created for each data point based on the document number in ATLAS.ti and the order of appearance in the text. This served as a reference in the analyses and allowed the researcher to revisit the original coded information in validating later decisions. The data was further analysed in MS Excel to determine each evaluation concept's *prevalence* (how often evaluation concepts appear) and *sentiment* (how the evaluation concepts are discussed) in pursuit of the first three aims specified in Section 5.1.

Prevalence was analysed by determining each concept's frequency of unique occurrence[4]. The prevalence contributes an initial indication of the relevance and applicability of the evaluation concepts. The analysis of the sentiment aimed to provide deeper insight about the evaluation concepts to meet the aims set out in Section 5.1. The coded data was considered in two primary analysis categories to analyse the sentiment which is presented in Table 5.1 along with the specific questions which guided the analysis and the corresponding aims the analysis aimed to meet.

The first category was concerned with the individual usage of evaluation concepts and the collective coherence in the way it was used in the resources. Each data point was considered individually against the existing understanding of evaluation concepts to determine whether a) it is used in an identical manner (falls exactly within the current understanding, b) it falls within the current understanding but uses different terminology, c) introduces a new understanding of the concept. After the information was considered individually, and the modifications documented, the information was analysed collectively for each code to determine whether the modifications or new aspects that emerged were still relevant to the concept or whether a new concept needs to be developed.

The second category was concerned with the co-occurrences between the evaluation concepts. Co-occurrences may be the result of ambiguity in how evaluation concepts are used or relationships between evaluation concepts. A co-occurrence matrix was compiled from the coded data that indicates the number of co-occurrences that took place between the different concepts. The set of evaluation concepts form both the rows and the columns of the matrix and the data points represent the number of co-occurrences. These co-occurrences were then further analysed to answer the corresponding guiding questions.

[4] Unique in that 1) the concept is applied to different aspects of the task/technology; or 2) the concept appears in relation to different individuals – even if it is the same task/technology

Table 5.1 Analysis of the evaluation concept sentiment in the theoretical case study

Analysis category	Guiding questions	Corresponding aims
Individual usage and collective coherence	What trends are there in the way evaluation concepts are used?	Determining the relevance and applicability of the evaluation concepts. Refining and contextualising the evaluation concepts.
	What new facets emerge in the way the evaluation concepts are used?	
	What new concepts emerge?	Identification of additional evaluation concepts.
Co-occurrences	What ambiguity exists between evaluation concepts from the analysis of co-occurrences?	Refining and contextualising the evaluation concepts.
	What relationships exist between evaluation concepts from the analysis of co-occurrences?	Suggesting relationships between the evaluation concepts.

The findings of the analysis are discussed in the following sections along with how these are leveraged to achieve the design cycle aims.

5.4. Adaptations to evaluation concepts

In this section, the results of the analysis and the consequent adaptations to the evaluation concepts based on the findings are discussed.

The prevalence of the different evaluation concept inventory concepts in the case study is depicted in Figure 5.1. It is important to note that the prevalence of concepts in the case study is not an indication of the concept's importance in the evaluation. The prevalence of the evaluation concept inventory concepts does however give a positive initial indication of its relevance and utility, as formerly discussed. Similarly, the absence of evaluation concept inventory concepts in the case study give the initial impression that these may be irrelevant. Further investigation of the sentiment in applying the evaluation concept inventory concepts was however required in both cases to confirm these indications.

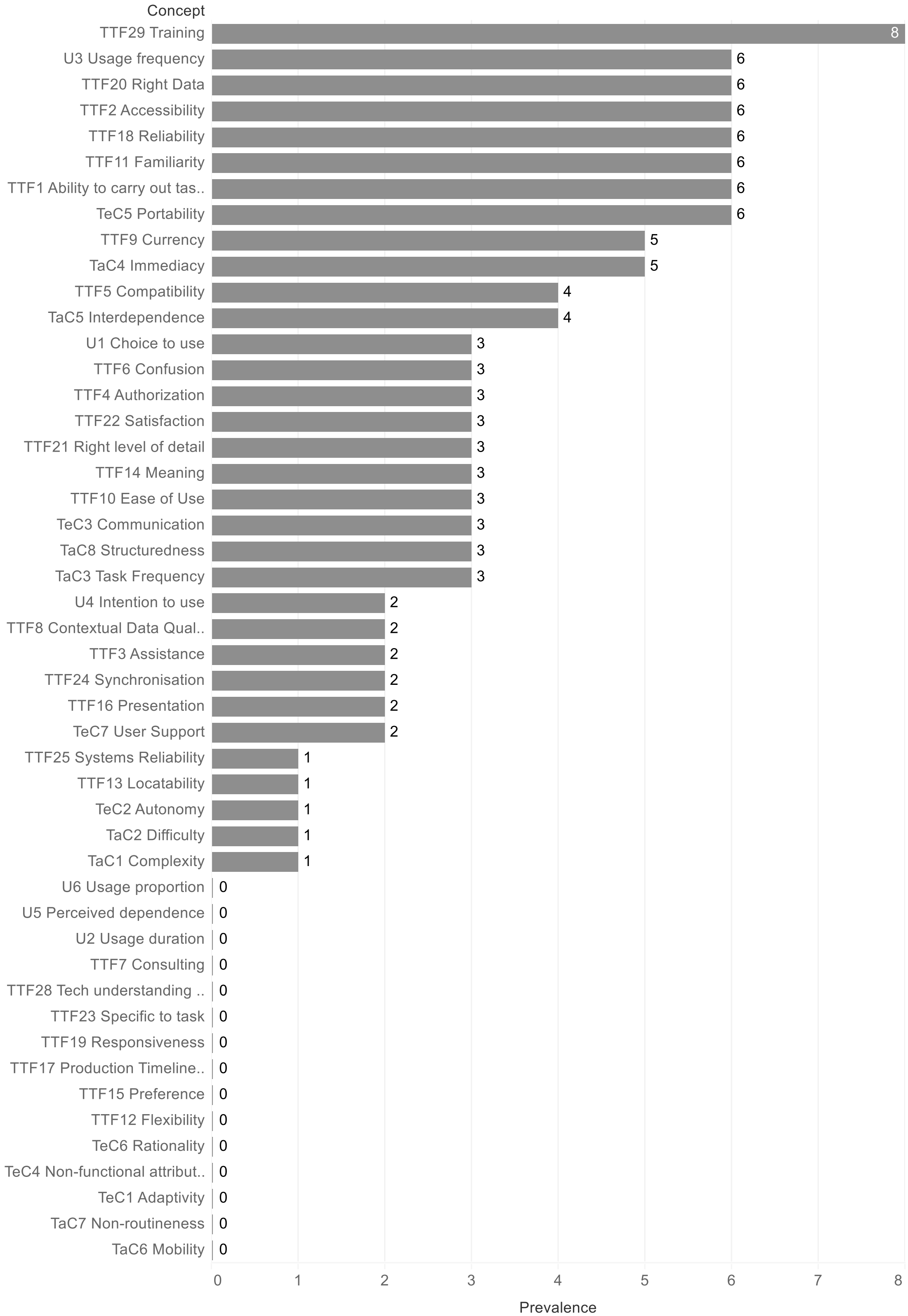


Figure 5.1 Prevalence of TTF concepts in the case study

In the investigation, four trends were identified in comparing the coded data of this case study to the concepts in the evaluation concept inventory, depicted in Figure 5.2, which allowed for the aims of the chapter to be achieved as indicated in the figure. These trends are related to the existence and non-existence of concepts.

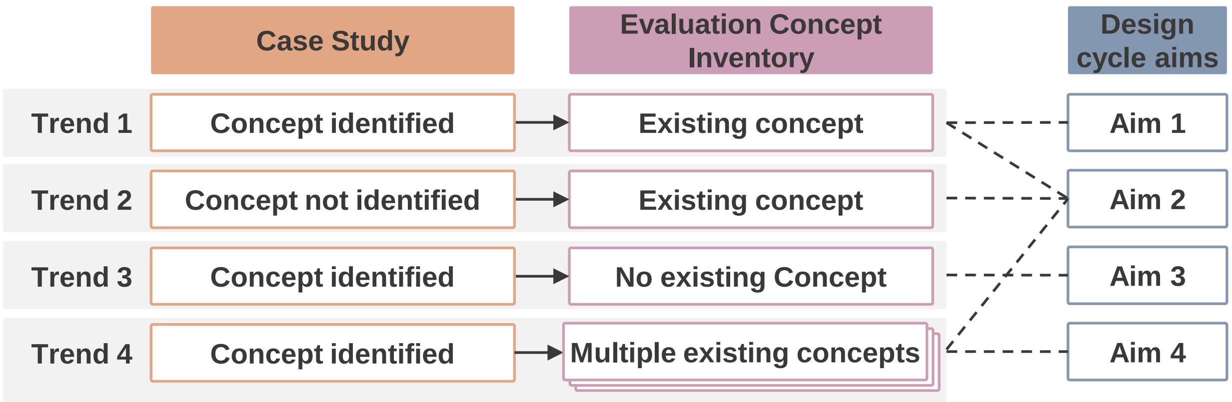


Figure 5.2 Trends of concept usage in the case study

Firstly, in most cases, the concepts that were identified in the case study used language that was coherent with the theoretical descriptions in the evaluation concept inventory. This confirmed the relevance and applicability of these evaluation concepts. In certain cases, terminology was used that contributed to a deeper, and wider, understanding of relevant vocabulary in referring to the different concepts. This was used to refine and contextualise the corresponding evaluation concepts. In APPENDIX C, the final set of evaluation concepts used in this study is provided along with an indication of which concepts were modified based on these findings.

In analysing the case study data associated with *Data Quality*, the evaluation concept inventory description was found to be too limited. In Chapter 3, *Data Quality* was conceptualised, as suggested by Glowalla and Sunyaev (2014), in the contextual sense – based on the data's fitness for use. In the case study, it was found that although this conceptualisation is suitable for describing TTF, it is insufficient for the evaluation purposes set out in this study. When considering aspects related to data's fitness for use, it allows for description of the phenomena and contributes further insight into the process of identifying potential causes.

In the context of the Stock Visibility System, an experienced facility manager may recognise that the information displayed by the system is incorrect (considering the "*Right data"* concepts). No insight is however given as to whether the problem was due to a problem with the technology or an error made by the user during data collection. Data quality should therefore not be separated from, what Glowalla and Sunyaev (Glowalla & Sunyaev, 2014) refer to as, *Intrinsic Data Quality,* that is, the context-independent aspects of data quality which are objective. Four concepts related to intrinsic data quality, as defined in the *WHO's Data Quality Review* (World Health Organization, 2017a), were therefore added to the list of existing concepts namely, completeness, timeliness of information, internal and external consistency.

The second trend was that a number of cases were not identified as part of the case study despite being found in the evaluation concept inventory. The descriptions of these concepts were analysed to determine whether it may be of relevance to the broader study despite not occurring to this case study. Of the 11 concepts that were not applied, three concepts (*Usage proportion*, *Specific to task*, *Non-routineness*) were adjudged to be of potential relevance for the broader study based on their descriptions. The remaining eight concepts were consequently removed.

Thirdly, a number of concepts identified in the case study were coded “other” as, on a surface level, it appeared there were no existing relevant concepts in the evaluation concept inventory. These data points were analysed in more detail following the process depicted in Figure 5.3.

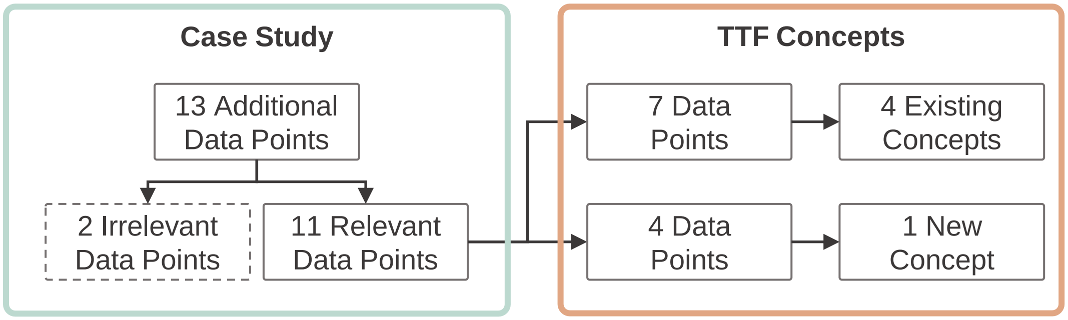


Figure 5.3 Review process of supplementary codes

The codes were first reviewed to determine whether they were actually of relevance to this study, and two items were dismissed. The remaining data points were compared to the existing concepts and it was found that seven of the data points related to existing TTF concepts. In the analysis of the remaining data points, it was found that all four data points referred to the same phenomena and a single, new concept, value perception, was therefore added to the evaluation concept inventory.

In the case study resources, evaluators described the importance of system users perceiving the value of the overall system, and based thereon, the importance of their individual roles therein. In situations where this is not the case, it was found that users saw their tasks as redundant and became reluctant in correctly and timely completing these tasks. Based on this insight, the concept *value perception* was added to the evaluation concept inventory.

The final trend was identified as a number of concepts in the case study was associated with multiple concepts from the evaluation concept inventory. A total number of 46 co-occurrence instances was found in the case study. These co-occurrences were further analysed, revealing three primary causes: ambiguity in case study terminology; ambiguity in evaluation concept inventory concepts; and relationships between evaluation concept inventory concepts.

The ambiguity in the case study terminology was expected as the resources used each had their own aims and were not specifically guided by the concepts of this study. None of the concepts in this causal category therefore resulted in any changes to the existing set of evaluation concepts in the evaluation concept inventory. The co-occurrences related to ambiguity in the evaluation concept inventory concepts were however essential to revise for this study and resulted in the modification of five concepts.

The discussion of the four trends that emerged from the analysis and the adaptations to the evaluation concepts based thereon achieve the first three design cycle aims. The suggestion of concept relationships informed by the co-occurrences of evaluation concepts is discussed in the following section.

5.5. Suggestion of evaluation concept relationships

The identification and consequent suggestion of relationships between the evaluation concepts meet the final design cycle aim and is discussed in this section.

The relationships between the evaluation concepts are argued to be valuable as it contributes to understanding how concepts should be used in describing and evaluating CBHIS. The relationships between the evaluation concepts may provide more comprehensive evaluation insight compared to isolating individual concepts. Since a number of evaluation concepts are related to each other, the interactive tool should incorporate these links between different concepts in making value judgements.

For each of the co-occurring concepts, a note was made whether a perceived relationship exists between the concepts or not. Thereafter, the evaluation concept inventory concepts were analysed to identify further possible relationships that are not present in the co-occurrences. The identification of these relationships does not aim to provide a comprehensive set of conceptual relationships; rather, it seeks to identify a set of relationships which may be of practical value for the interactive tool.

A challenge was presented in how the two categoric concepts, *Intrinsic Data Quality* and *Contextual Data Quality*, should be incorporated since these are simply collective term for a set of concepts and have no intrinsic properties of evaluation applicability. Furthermore, the complexities of the various relationships associated with these categoric concepts may result in confusion where the relationships are used to guide the evaluations. The complexities may be demonstrated by Scenario 1 depicted in the Figure 5.4. Since *A* is depicted as related with the categoric concept *B*, and *X, Y* and *Z* are related to *B*, *A* is therefore related to *X, Y* and *Z*. Although *P* is related to *Z*, it is not related to *X* and Y, despite the fact that *X, Y* and *Z* are part of *B*.

Although the former relationships associated with the categoric concepts are logical and reduces the overall number of relationships, the removal of the categoric concepts, and subsequent direct linkages of concepts, is expected to be of greater utility; it was therefore selected as a more useful approach. Scenario 2 in Figure 5.4, depicts the preferred approach in which the categoric concept was removed.

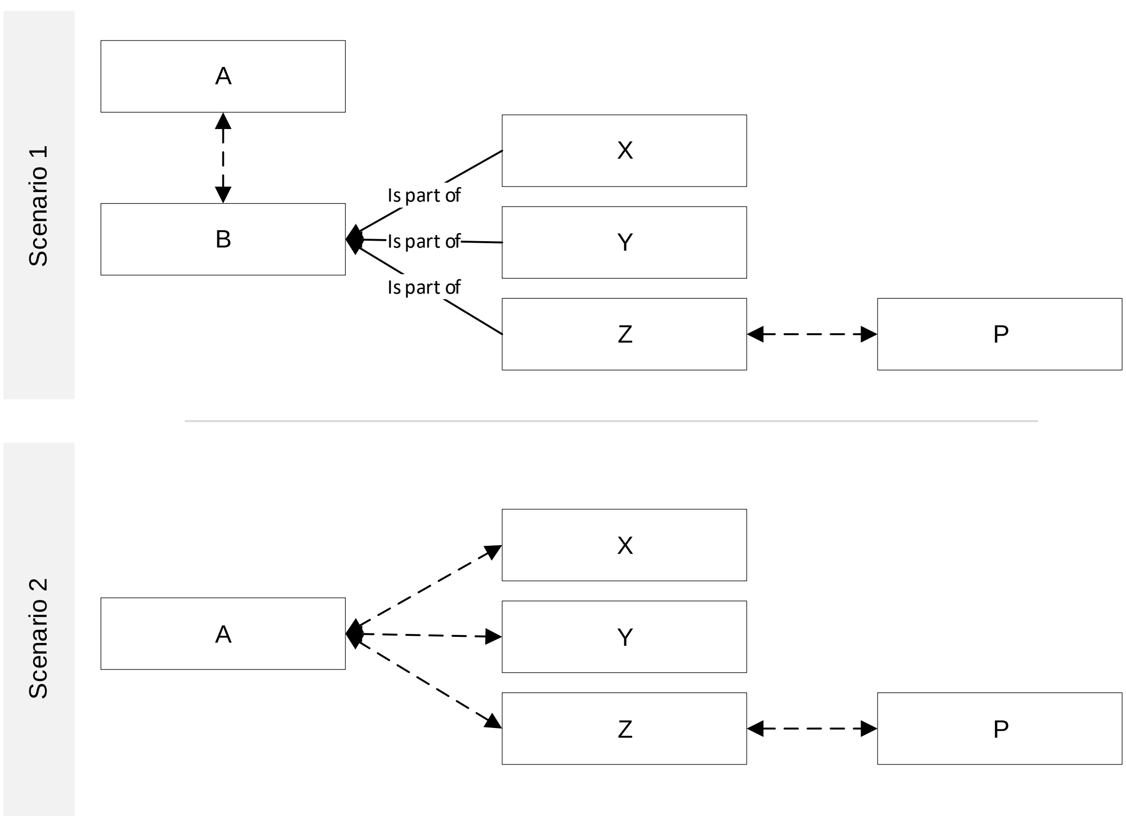


Figure 5.4 Example of categoric relationships

The final set of relationships identified were visually presented as a first draft concept map of which an excerpt is depicted in Figure 5.5. A concept map consists of nodes and links to show the relationship between nodes, which are the evaluation concepts in this study (Novak & Cañas, 2006). The ATLAS.ti software, used for data analysis in both the scoping review (Chapter 4) and the theoretical case study, was used to develop the concept map as it provides the capability of visually establishing the relationships between concepts. Furthermore, the software allows this information to be exported into a comma-separated values file which may be processed in other software.

This first iteration of identifying and mapping the relationships between evaluation concepts corresponds with, what Maxwell (2013, p. 22) identifies as no-risk maps "in which all the concepts are global and abstract and contains two-directional arrows everywhere". He emphasises that, although these may be initially useful in providing conceptual clarity for a study, it is important to focus on relationships, identify unidirectional relationships and make commitments in specifying the nature of the relationships. An explicit description of the nature of these relationships would therefore be of value for further development of the interactive tool.

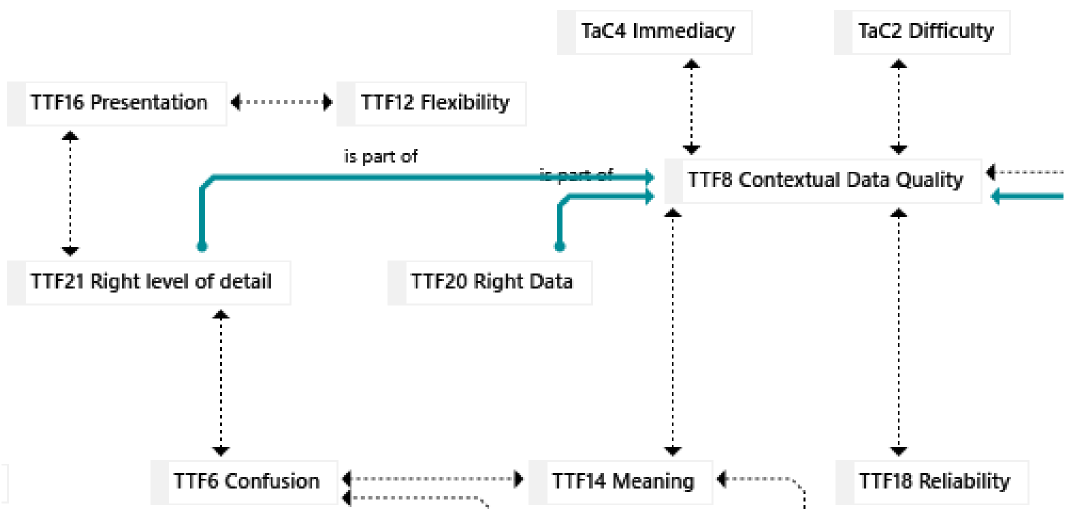


Figure 5.5 Except of first draft concept map depicting relationships between evaluation concepts

All of the relationships were reconsidered to formalise the relationships with the intention of providing greater clarity as to the nature of their respective relationships. The generic process followed in clarifying the relationship between any two concepts is depicted in Figure 5.6. The relationship between two concepts is considered in both directions to verify which direction the relationship exists in and what the nature of the relationship is.

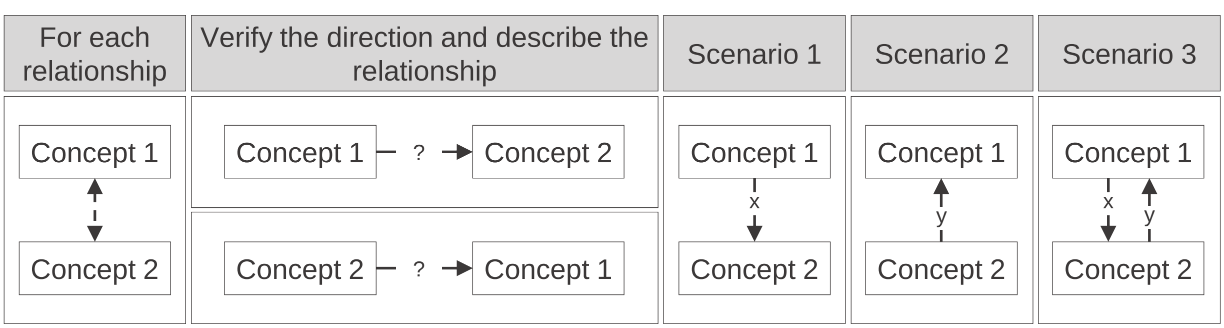


Figure 5.6 Process followed to refine the relationships between concepts

This may be demonstrated by two hypothetical examples. Firstly, considering two concepts, *light sources* (concept 1) and *visibility in workspace* (concept 2) part of an analysis of a working environment, it is determined that concept 1 *is a factor of* (nature of the relationship) concept 2. Other than being the inverse of the former, concept 2 is however not related to concept 1 in a relevant manner and is therefore depicted as a single unidirectional relationship, described by Scenario 1 in Figure 5.6.

Secondly, considering two concepts, *assignment difficulty* (concept 3) and *assistance* (concept 4) part of an analysis of an educational environment, concept 3 *creates the need for* (nature of the relationship) concept 4. In this example, concept 4 *decreases* (nature of the relationship) concept 3 and is therefore depicted with two unidirectional relationships, described by Scenario 3 in Figure 5.6.

There exists no standard or exhaustive set of descriptive terms to define the nature of the relationships between the evaluation concepts. Rather, these relationships are described based on the context and purpose of the study (Maxwell, 2013; Novak & Cañas, 2006). The aim was to ensure that the relationship descriptors be *concise* and *self-explanatory* on an individual level as well as *coherent* across all the relationships. The set of relationship descriptors applied to the concepts are described in Table 5.2. The concept map, in which the relationships described in Table 5.2 are incorporated, is presented in APPENDIX D.

Table 5.2 Relationship descriptors that define the nature of relationships between evaluation concepts

Relationship descriptor	Description	Link identification
Contributes to	The former concept is identified as potentially contributing to the latter concept. This relationship may reveal insight as to multiple concepts which influence the prominence of the initial concept considered. **Example**: Information being presented in an appropriate manner *contributes to* the user finding the information meaningful.	
Prioritises	The prominence of the former concept provides grounds for the latter concept to be considered in greater detail (thus *prioritises*). **Example:** If decisions are urgent then the information presented needs to be timely.	
Is a consideration for	The former concept provides an additional consideration for the latter concept. **Example:** If tasks are not routinely performed then the timeliness of the data collected will be affected and the way timeliness is considered should be different to routine tasks.	

The suggestion of the concept relationships in this section meets the final design cycle aim. In the following section, the limitations of the case study are discussed.

5.6. Limitations of the case study

A number of limitations are acknowledged in conducting the case study. Despite having access to documentation, the range and volume of the documentation was limited. The original interview manuscripts and survey data, from which the discussions in the available documents were derived were not available. Only information which has been synthesised by the evaluators or researchers was therefore analysed, which may lead to potentially biased results.

The theoretical case study serves as a first refinement iteration for the development of the interactive tool and a number of further refinement iterations form part of the overall development, as discussed in the study design (Section 2.4). Therefore, although the theoretical case study conducted in this chapter presents limitations, the risk of misinterpreting certain information, and individual bias is mitigated by the succeeding design cycle iterations which reinforce the relevance and rigour of the interactive tool.

Yin (2003) identifies three major limitation concerns of case study based research. The mitigation of these concerns in this study to ensure the effectiveness of the case study, and to achieve its objectives is described in Table 5.3.

Table 5.3 Mitigation of general case study concerns (Yin, 2003)

Concern	Mitigation of the concerns in this study
Lack of academic rigour due to sloppy methodology	Careful attention is paid to the design and execution of the case study. This is achieved by following the methodology discussed in Section 2.4.3 and clearly documenting the entire process.
Little basis for scientific generalisations	The research aims to develop useful and relevant interactive tool rather than completely generalisable one to support CBHIS. Therefore, to ensure relevance and utility, the case study method is used in conjunction with the scoping review and the semi-structured interviews.
The case study process can be unduly lengthy	This concern typically applies to where ethnographic participant observation is involved. In this study, the case studies only consider data collection from existing documentation. Documentation is a stable and unobtrusive source that allows investigators to cover a broad span of events and time period. In this study, the documentation used is limited to administrative documents, such as proposals and other internal documents, and formal studies or evaluations previously conducted (Section 5.2).

As acknowledged in Section 4.9, the set of evaluation concepts included in the inventory contain numerous intricacies, span numerous research domains and are often the research focus of many studies. Since the relationships between the TTF concepts are not explicitly considered in the TTF literature, the process to theoretically ground each relationship suggested in this section is a complex and highly demanding study in itself. This study does not aim to make a scientific claim about the existence and extent of relationships between the evaluation concepts. Rather, based on the researcher’s interpretation, it aims to suggest relationships which may be useful to provide a more insightful evaluation. Although the relationships are subjected to the researcher’s interpretation, interviews with subject-matter experts, which are discussed in the following chapter, provide a means to validate the logic, identify potential errors and omissions, and add to the rigour thereof.

Having achieved the design cycle aims and discussed the limitations of the case study, the concluding remarks of the chapter are discussed in the following section.

5.7. Concluding remarks: Chapter 5

In this chapter, the design cycle aims were met through the completion of the third design cycle iteration; it consists of an *evaluate* and *develop* component executed through conducting a theoretical case study, as depicted in Figure 5.7. The case study allowed for the investigation of the evaluation concepts in relation to the Stock Visibility System, a stock management CBHIS implemented in clinics across the country, thereby contributing to the relevance of the development process.

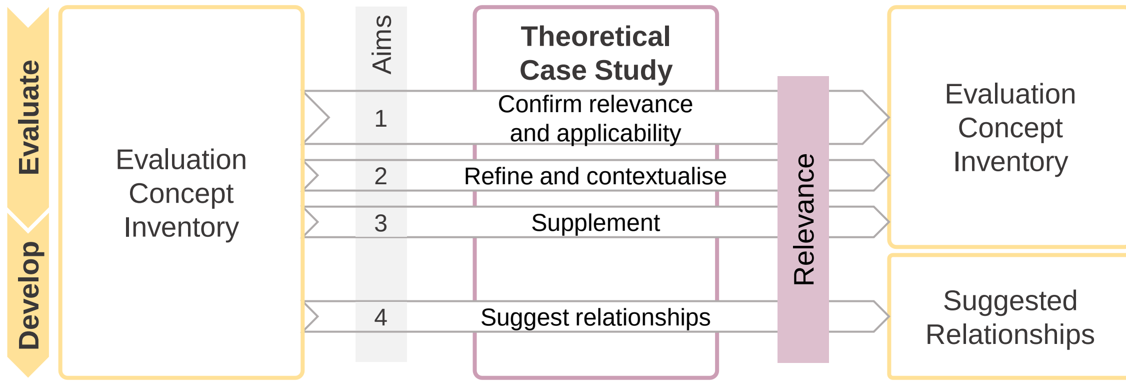


Figure 5.7 Completion of the third design cycle iteration

The analysis of the case study data in the evaluation component of the design cycle iteration achieved the first three design cycle aims. Firstly, the relevance and applicability of the evaluation concepts to the application environment were determined, and those that were found to be irrelevant or inapplicable were removed from the inventory. Secondly, the remaining evaluation concepts were refined and contextualised to the application environment. Finally, the evaluation concept inventory was supplemented by identifying additional evaluation concepts from the analysis of the case study data.

The adaptations made to the evaluation concept inventory in this chapter contribute to the alignment of the evaluation concepts to this study such as to be both relevant and applicable to the application environment. This also contributes towards the fulfilment FR1 of the tool development requirement which is concerned with the terminology used in the tool (Section 3.4.1). The evaluation concept inventory is considered the first component of the interactive tool, providing users with a tangible set of evaluation concepts that may be considered for, to inform, or to focus CBHIS evaluation efforts.

As discussed in Chapter 4, the evaluation concept inventory also provides the conceptual basis from which the interactive tool may be further developed. This was pursued in the development component of the design cycle iteration. The analysis of the case study data was leveraged to inform the suggestion of relationships between the evaluation concepts, presented as a concept map, and thereby achieve the fourth and final design cycle aim.

These suggested relationships form the second component of the tool and provides two major contributions for this study. Firstly, it provides a means to consider the interrelated nature of the concepts to guide a more comprehensive evaluation of multiple socio-technical aspects of a system which influence each other. Secondly, the relationships depicted in the concept map form a structure which may be leveraged to meet FR2 of the tool development requirements and is pursued in Chapter 7.

Having adapted the evaluation concept inventory and suggested relationships between the evaluation concepts, these components were evaluated by multiple subject-matter experts by conducting semi-structured interviews; this is further discussed in the following chapter.

Chapter 6. Subject-matter expert interviews

6.1. Introduction

In Chapter 5, adaptations were made to the evaluation concept inventory to align the evaluation concepts with the aim of this study and relationships between the evaluation concepts were suggested and depicted as a concept map. In this chapter, the completion of the fourth design cycle iteration is discussed; it aimed to:

1. Validate the appropriateness of how the TTF theory has been applied;
2. Confirm the relevance and rigour of the evaluation concept inventory and the suggested relationships;
3. Adapt the evaluation concept inventory and the suggested relationships to ensure its relevance and rigour; and
4. Obtain focused insights for further development of the interactive tool.

These aims are achieved through conducting semi-structured interviews with multiple subject-matter experts (SMEs) and leveraging the findings. This approach was selected as it provides a structured yet flexible means of investigating the evaluation concepts, the suggested relationships and exploring how these may be leveraged to support the evaluation of CBHIS, thereby achieving the former aims. The semi-structured interviews followed the procedure discussed in Chapter 2. The following stages of the procedure are discussed in this chapter: defining the interview purpose (the aims described in this section); identifying participants (Section 6.2); designing the interview protocol (Section 6.3); and the presentation of the findings (Sections 6.4-6.6).

6.2. Identification of the interviewees

Three categories of interviewees were identified based on the aims of the design cycle iteration of the interview and the work completed in this study; each category provided specific insight in pursuit of the aims.

The analysis of TTF theory provided a tangible set of evaluation concepts for the development of the interactive tool. The concepts extracted from TTF literature were interpreted by the researcher to suggest useful relationships between the concepts (See Chapter 4 and Chapter 5). The first category of interviewees consists of individuals who may be consulted to evaluate the evaluation concept inventory and suggested relationships based on their expertise on the TTF theory, thereby reinforcing the rigour of both components. These individuals may be identified as those who have conducted significant research on the TTF theory or have practical experience in the application thereof. Interviews with individuals from this category contribute to achieving the design cycle aims 1-3.

As identified in Chapter 2, and discussed in Chapter 3, the interactive tool developed in this study is positioned within the M&E domain and the development process guided by insights therefrom. The second interviewee category therefore considered individuals who have expertise in M&E, specifically that of CBHIS, thereby reinforcing the relevance to all three primary, overlapping domains discussed in Chapter 2. The interactive tool is developed for the CBHIS context. The third interviewee category therefore considered individuals who are involved in the development, implementation, or usage of CBHIS, thereby reinforcing the relevance of the interactive tool to the overlapping IS and PHC domains. Interviews with individuals from both categories aim to contribute to achieving the design cycle aims 1-3.

A number of potential interviewees were identified for each category with the assistance of the research supervisors and contacted with a request for participation in this study. A total of four SMEs participated in the interviews and are introduced in the following section to provide background to the participants and establish their relevance.

The first interviewee has a background in education and the evaluation of management IS in the educational environment. The interviewee is well acquainted with the TTF model through the research conducted for their PhD, which adopted various existing models to develop a methodology to evaluate IS in the technical vocational education and training college environment.

The second interviewee has worked across a number of different domains including Health Information Systems. They completed their PhD in IS and have since been extensively involved in technology consulting with projects of interest such as the identification of appropriate technology its deployment in the rural South African context. The interviewee's exposure to the TTF theory was within the context of projects that consider the effect that technology deployment has on individuals in an environment and the formulation of strategies to evaluate how technology can be introduced to ensure its effectiveness.

The third interviewee has multiple years' experience in the M&E of IS. They completed a Master of Business Information Systems degree and a PhD in Information and Communication Technologies in education. Since 2009, they have been involved in various projects related to the research, design, and implementation of M&E on ICT interventions. The organisation that the interviewee is associated with provides support to the National Department of Health on various digital health projects and assists in the M&E of these respective projects. Of particular relevance to this study, the interviewee has been involved in the evaluation of three major CBHIS implemented by the National Department of Health, published a number of articles, and supervised various PhD students in the field of M&E.

The final interviewee has been involved in numerous national CBHIS initiatives in South Africa and other African countries. They are currently responsible for managing the operation, maintenance, and ongoing development of a CBHIS commissioned by the National Department of Health and deployed in health care facilities across ten provinces in South Africa. The interviewee has in-depth experience of CBHIS and is able to provide insight across all the life cycle phases of the system as well across different stakeholder groups.

6.3. Interview protocol

The semi-structured interview was selected to collect relevant data from the subject matter experts to achieve the interview purpose. Yin (2003) suggests that a discussion guideline be developed in conducting the interviews to ensure that the purpose of the interview is achieved. Two different discussion guidelines were developed based on the interview purpose (Section 6.1) and an overview of these are provided in APPENDIX E.

The interviewees were provided with a brief overview of the research, the discussion guideline, the evaluation concept inventory and the visual depiction of the suggested relationships in the concept map[5] at least 24 hours before the interview to familiarise themselves with the content that would be discussed.

The discussion with the interviewees presented challenges due to the large number of concepts and relationships that needed to be validated. All of the interviewees agreed to review the concepts and relationships after the discussion and provided feedback once completed.

The recordings of the interviews and post-interview feedback were analysed, and the findings of these interviews are discussed in the following sections.

6.4. Interview findings: Task-Technology Fit theory experts

Based on their contexts, the SMEs considered the TTF theory from a number of perspectives: user-technology adoption, user's perspective of technology, technology appropriateness and impact as well as the organisational consideration for technology implementation. This provided further confirmation of the TTF theory's flexibility in application to suit a wide variety of objectives, as initially identified in the discussion of the TTF literature (Section 4.4). The interviewees also validated that the application of the TTF model in this study was done in an appropriate manner and that both the overarching assertion of the theory as well as its constituents thereof are clear in the application.

In the review of concepts, the interviewees pointed out that most of the concepts are described in a positive manner; they noted that *TTF6 Confusion* is the only concept expressed in a negative manner and should therefore be reconsidered. It was discussed that the inverse of the concept, i.e. *TTF6 Clarity*, should be adopted to replace the original concept. The description of the concept was further investigated, and it was found that no aspects of the concept would be lost if an inverse concept is accepted.

The interviewees also identified *TeC4 Non-functional attributes* as ambiguous. Interviewees asked why "functional attributes" do not appear. This concept refers to aspects such as the hardware-related components that contribute to the overall functioning of things such as the processing power and display brightness. The concept was therefore renamed to *Auxiliary attributes.*

An additional concept was suggested by the interviewees which reflects the actual utilisation of training by the users. It was emphasised that training might be available (*TTF29 Training availability*) and appropriate (*AC7 Training quality*), but if it is not utilised then it will also not result in the desired outcomes. Furthermore, a number of minor modifications were made to the wording of the concept descriptions to ensure clarity. The final evaluation concept inventory presented in APPENDIX C indicates where such modifications were made.

The interviewees agreed that the types of relationships suggested are logical for the purposes of this study and did not recognise any further types of relationships that should be incorporated. A number of adaptations were made to the set of suggested relationship based on the discussions and the formerly discussed adaptations to the evaluation concept inventory.

The interviewees noted that they expected a number of evaluation concepts to contribute to *Timeliness, Completeness*, *Internal consistency* and *External consistency.* In the discussions it was identified that the

[5] After each interview, both the evaluation concept inventory and concept map were updated based on the findings such that the following interview evaluates the latest version of each.

suggested relationships are primarily from the perspective of a CBHIS user interacting with existing information rather than a user who is responsible for generating information. With the assistance of the SMEs, an additional set of relationships were suggested for data collection type usage of CBHIS following the process depicted in Figure 6.11

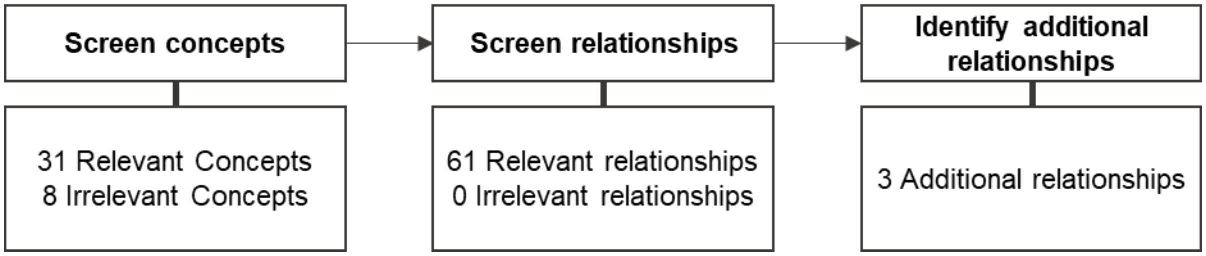


Figure 6.1 Process followed to identify concepts and relationships

The concepts were screened with the assistance of the SMEs to eliminate concepts that would not be of relevance for data collection purposes. This included concepts such *Reliability,* as the data collector is not presented with any information, rather they simply input data into the system. With the remaining concepts, the existing relationships were considered and were all found to be of relevance. Three additional relationships were identified through the insights provided by the interviewees and were added to set of suggested relationships.

The evaluation concept inventory and the suggested relationships were further evaluated by an M&E subject-matter expert; this is discussed in the following section.

6.5. Interview findings: Monitoring & Evaluation expert

The interviewee emphasised that the design, development, and implementation of CBHIS require large amounts of resources, effort and typically span a number of years, which may be attributed to a number of factors. The information generated and used in the health care environment is both important and sensitive; requires meticulous design, development, and implementation. The systems are also used on a large scale and necessitate the integration with existing systems and standards, which add to the complexity of the system and the effects thereof. The interviewee highlighted that several other challenges are faced in South Africa due to the diversity between facilities with factors such as language, education, and experience with technology. All of these former aspects necessitate feedback to be provided to stakeholders about various elements of the system. Therefore, as stated by the interviewee, "Evaluation is crucial to show evidence of efficacy, utilisation, success and impact".

The evaluation concept inventory and concept maps for both system tasks were presented to the interviewee for a discussion on the relevance and utility of the concepts for evaluating CBHIS in general – rather than considering it with respect to a specific system. This approach was taken due to the experience and expertise of the interviewee in the evaluation of CBHIS.

The interviewee noted that all the concepts are important from a general M&E perspective and that their respective descriptions are sufficient. Depending on the area of application, specific concepts may be more, or less, important to stakeholders but none should be removed from the inventory. It was also reemphasised that the aspects of a system that is evaluated largely depends on the objectives and perspective of the evaluation, thereby the dictating specific aspects to be analysed. Based on what this study aims to achieve, the interviewee confirmed the relevance and utility of the evaluation concept inventory concepts within their environment.

In further discussion of evaluation considerations, the subject-matter expert spoke about the necessity of *interoperability* between different CBHIS. The interviewee defined interoperability as, “The integration of various IS that requires link to each other to provide the same level of data quality”. The concept may be explained by the hypothetical scenario in which a patient is electronically prescribed medication by a doctor at a health care facility which is then collected from a nearby pharmacy after which the patient is billed. The systems used in the healthcare facility to prescribe and pharmacy to dispense and bill the patient all need to communicate the correct information to each other despite being separate systems. Interoperability is required to ensure the accessibility of information between systems. Poor interoperability thereby directly contributes to the problems identified in Section 1.2 and hence added to the evaluation concept inventory based on its relevance to this study.

The discussion around *Interoperability* revealed the similarities with the existing description of the *compatibility* concept in the evaluation concept inventory. It was discovered that the conceptualisation of technological compatibility has evolved over time, as other concepts such as interoperability gained prominence. It was pointed out that compatibility is concerned with the human interface between multiple systems, whereas interoperability is concerned with the interaction between the systems. These insights were found to be consistent in the conceptualisation of these terms in a number of studies (de Oliveira & Peres, 2015; Hamamura et al., 2017; Hammami et al., 2014; Medford-Davis et al., 2017; South Africa. Department of Health & CSIR, 2019), and the respective descriptions were consequently modified.

The interviewee confirmed the observations made in Section 4.9 that a number of concepts in the evaluation concept inventory contains numerous intricacies, span numerous research domains and are often a focus of research themselves. Furthermore, the interviewee stated that evaluation objectives and the context in which the evaluation is conducted will result in the concepts having varying importance and specific aspects that would be close consideration.

Furthermore, despite agreeing with all the relationships depicted in the concept map for both system tasks and not identifying any omissions, the interviewee observed that the structure of the concept map was found to be confusing. Since no explanation was provided for how the concept map was structured or how it may be used, the interviewee’s impression was that concepts depicted at either the outer or innermost of the map were the most important or a potential starting point. The interviewee suggested that the concept map be structured in a hierarchal manner. However, due to the quantity and complexities of the relationships in this study, even if a hierarchal structure is adopted, the large number of relationships still result in the concept map being complex and impractical. It is therefore necessary to explore alternative ways of structuring the concept map and further developing it to be of practical value for investigators.

6.6. Interview findings: Clinic-based health Information System expert

The CBHIS expert emphasised that the evaluation of these systems is essential; this is similar to the finding discussed in Section 6.5. The final interviewee did however provide an additional perspective from the former interview based on their role within CBHIS development and operation.

CBHIS that are developed by non-state-owned entities, such as the organisation that the interviewee is associated with, are typically funded by national or provincial ministries of health. This creates the situation, as depicted in Figure 6.2, where the ministry of health is the client of the developers, but the users of the product are other individuals within the health system.

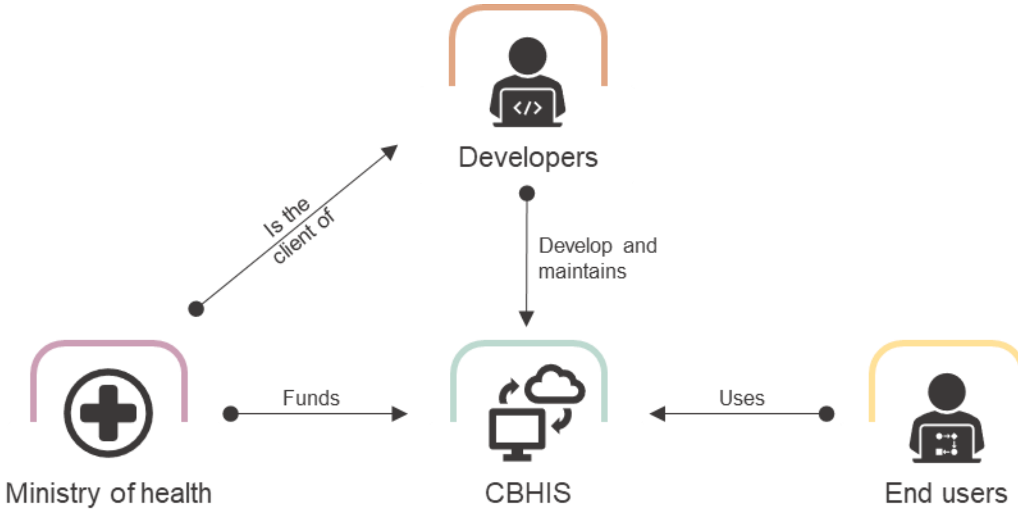


Figure 6.2 Major stakeholders in CBHIS developed by non-state-owned entities

The interviewee pointed out that these evaluations allows the developers to focus on the experience of the end user and determine whether value is added. These evaluations typically focus on adoption, usage, impact, or specific aspects of the system and are conducted either by the system developers or by independent third parties. External evaluations are primarily conducted to objectively provide feedback to the clients on the impact of the system. Internal evaluations are more focused on specific components of the system and its usage.

The organisation analyses trends from both the data collected by users, system usage data and data from the support services to identify areas that require further investigation. The relevant people in the field are then consulted as part of the evaluation process to provide detailed account for the aspects of the system under investigation. Therefore, although quantitative data may show where to look, it is important to speak to people within their environment to get a sense of what is really going on. This affirms the importance of the explanatory approach adopted in this study (see FR4 in Section 3.4).

The interviewee pointed out that no standard tool or framework is used by the organisation for the evaluation process; rather, they rely on organisational experience for conducting the evaluation. In the discussion around what they typically consider within these evaluations, various concepts from the evaluation concept inventory were found to be continuously monitored by the organisation. This provided particular insight into the relevance and applicability of these concepts, as summarised in Table 6.1.

Table 6.1 Evaluation concept inventory concepts routinely investigated for the relevant CBHIS

Concept	Insights from interview
U3 Usage frequency	The trends in usage frequency (compared to what is expected) are one of the most important indicators for the organisation for potential problems in the system. During the implementation phase of a system, they are also used as a measure of the system adoption rate.
AC1 Value perception	As discussed in Section 5.4, when users primarily use the system to collect data, the tasks they are performing do not typically add direct value to them. Not understanding what the larger system is achieving often results in the system being neglected or used incorrectly.
AC7 Training quality and TTF29 Training availability	Both the quality of training, and the availability of further training as required, play an important role in the system being used correctly. They also contributes to the users understanding of the importance of their role within the bigger system, thereby contributing to the value perception.
TTF3 Assistance	The availability of assistance (offered in the form of a support desk within the interviewee's organisation) also creates a platform for the developers to quickly identify system related problems.
TTF24 Synchronisation	Since an increasing number of systems are reliant on mobile technology, a common issue is found to be with the synchronisation of information from and to the devices. Synchronisation issues may therefore result in the false perception that the technology is either not being used or used incorrectly.
TeC4 Auxiliary attributes	The hardware plays an important role of collection and synchronisation of legitimate data.

The interviewee noted that the *Flexibility* concept is referred to as *Configurability* within the application environment. This term is also more reflective of the description as flexibility may have numerous other connotations to it. The concept name was therefore modified to *Configurability* while the description was kept the same.

In the discussion of the evaluation concept inventory concepts in particular, the interviewee agreed that the high-level detail of the concepts is sufficient to support the evaluation as it provides clarity for what to consider and consequently assists in identifying potential problems. They confirmed that, with the scale and complexity of the concepts and their relationships, it is of more value to present the concepts, their descriptions and relationships in a simple manner that is easy to understand and apply rather than to attempt developing specific measures. Individuals who use the interactive tool may then further investigate the concepts for more information if necessary.

Due to time limitations, it was not possible to have a detailed discussion around each concept in the evaluation concept inventory. The interviewee did however agree to analyse all of the evaluation concept inventory concepts in detail in the time following the interview and provide feedback. In this feedback, the interviewee observed that all the concepts were understandable and that they did not identify errors or ambiguity in the descriptions of the concepts. The concept names were also expressed to be reflective of their related descriptions. They noted that, despite the apparent validity if the concepts, it may be useful to decrease the number of concepts as the interactive tool is further developed. This may be done by removing concepts that do not directly support the objectives of the interactive tool or dividing the concepts into smaller sets of concepts that answer different questions.

Regarding the suggested relationship, the interviewee confirmed the relationships expressed for both system tasks and did not identify any errors or omissions. They also reiterated what was identified in the previous interview, that the complexity of the concept map makes it difficult to understand and apply. Likewise, they also recommended that concepts should be presented in a simplified manner at the appropriate level of detail and with guidance for how it may be approached.

In the following section, the findings from the interviews are summarised and specific considerations for further development are discussed.

6.7. Concluding remarks: Chapter 6

In this chapter, the fourth design cycle iteration was completed; it consists of an evaluation component in which multiple subject-matter expert interviews were conducted to meet the design cycle aims, as depicted in Figure 6.3.. The interviewees were selected from three major domains of relevance to the research to ensure both the relevance and rigour of the work. These therefore included experts in TTF, the M&E of CBHIS as well as those involved in the development of CBHIS.

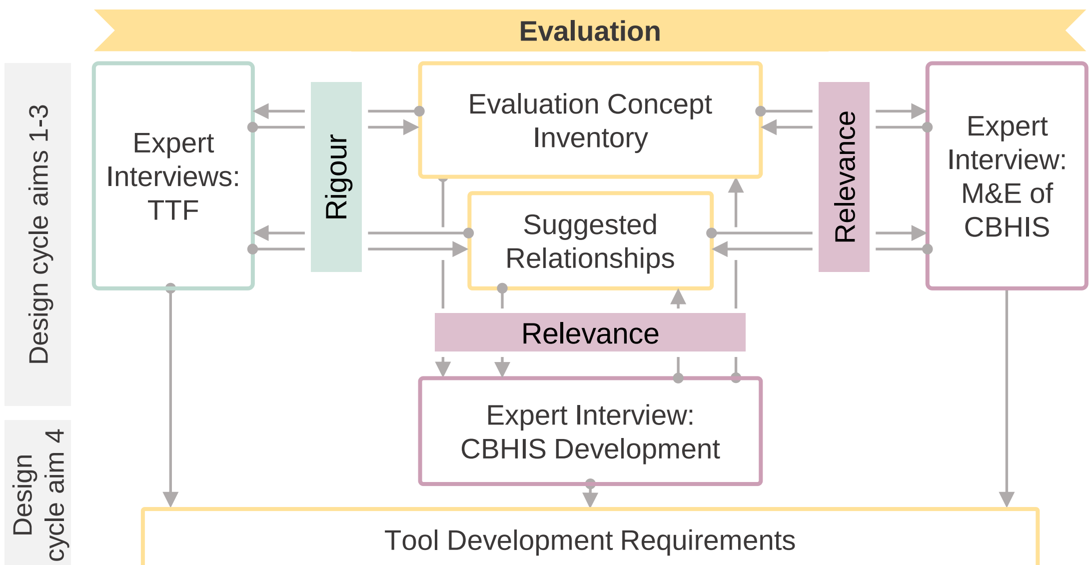


Figure 6.3 Completion of the fourth design cycle iteration

The findings of the interviews conducted with SMEs were leveraged to meet the aims set out in this chapter (Section 6.1). The first three aims were concerned with the evaluation concept inventory and the suggested relationships, the achievement of these are presented in Table 6.2 by summarising how the findings from the interviews were leveraged.

Table 6.2 Achievement of the first three design cycle aims by leveraging findings from the semi-structured interviews

Design cycle aims	Interviewee category		
	TTF Expert	M&E of CBHIS	CBHIS Development
1. Validate the appropriateness of how the TTF theory has been applied.	The theory was validated to be applied in an appropriate manner and was commended for its novel application.	-	
2. Confirm the relevance and rigour of the evaluation concept inventory and the suggested relationships.	All of the existing evaluation concepts were confirmed and the types of relationships suggested between the evaluation concepts were confirmed as logical.	Both categories of interviewees confirmed the relevance of the existing evaluation concepts. They also agreed with the suggested relationships and did not identify any omissions.	
3. Adapt the evaluation concept inventory and the suggested relationships to ensure its relevance and rigour.	Minor adaptations were made to the wording of the concept names, contributing to the rigour thereof and contributing to meet FR1 of the tool development requirements. A number of adaptations were made to the actual relationships. The biggest adaptation to the relationships was the identification of an additional set of relationships relevant to data collection tasks[6].	Various adaptations were made to the existing evaluation concepts to ensure that the wording best fits the environment, and additional concepts were added that were regarded to be of relevance to the environment. These contribute to the overall relevance of the tool and the meeting of FR1 of the tool development requirements. The SMEs also confirmed that the high-level descriptions are relevant for what the interactive tool aims to achieve.	

The achievement of these aims contributes to the relevance and rigour of the evaluation concept inventory and the suggested relationships between the evaluation concepts. This is of value to this study as it confirms the potential of these components to support the evaluation of CBHIS. Firstly, the evaluation concept inventory, by providing users with a tangible set of evaluation concepts that may be considered for, to inform, or to focus CBHIS evaluation efforts. Secondly the suggested relationships, by providing a means to consider the interrelated nature of the concepts such as to guide a more comprehensive evaluation of multiple socio-technical aspects of a system which influence each other.

In accordance with the final design cycle aim, a number of additional insights were gained through the interviews. Firstly, to both improve the comprehensiveness of the concept map and simplify the presentation thereof, the concept map was separated and appropriately refined into the two-primary user-system related interactions of information usage and data collection.

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[6] The final set of suggested relationships are presented in APPENDIX D along with a discussion around how the adaptations may be identified.

The interviews affirmed that the concepts and the relationships between the concepts have the potential to be of great value in supporting evaluations but that these still require further development. Two specific insights emerged which are used to focus the further development of the interactive tool. These insights were found to correspond with a subset of the tool development requirements discussed in Section 3.4 and are presented in Table 6.3 with the amendments to the requirements indicated in italics.

Table 6.3 Corresponding tool development requirements from the insights obtained from the interviews

<table>
<tr><th>Insights obtained in this chapter</th><th>Corresponding tool development requirement</th><th>Updated tool development requirements</th></tr>
<tr><td>The existing concept map is large and complex which makes it both difficult to effectively view and apply. The utility of the interactive tool is dependent on presenting the content in a simple and useful manner. This therefore requires further development of the interactive tool to consider how the existing concepts and relationships may be logically structured and presented.</td><td rowspan="2">FR2 Structure</td><td rowspan="2">The interactive tool requires a robust structure which is consistent with the causal logic and presented in a simple manner with only the necessary evaluation concepts.</td></tr>
<tr><td rowspan="2">Secondly, the interviewees observed that the current presentation of the concepts and relationships is not sufficient to understand how it is intended for application. Further development is therefore also required to guide the usage of the interactive tool through both the way it is presented and through explicit instruction.</td></tr>
<tr><td>FR3 Implementation guidance</td><td>The interactive tool should provide sufficient implementation guidance to ensure its utility while not over-constraining the interactive tool.</td></tr>
</table>

In the following chapter, the completion of the fifth design cycle iteration is discussed in which investigation lines of enquiry were formulated to meet FR2 of the tool development requirements.

Chapter 7. Investigation lines of enquiry

7.1. Introduction

In the previous chapter, the evaluation concept inventory and suggested relationships were evaluated by various SMEs and minor adaptations were made based on the findings. In this chapter, the completion of the fifth design cycle iteration is discussed; it aimed to:

1. Formulate a robust structure which is consistent with the causal logic and presented in a simple manner with only the necessary evaluation concepts;
2. Specify an application process for the structure; and
3. Review the logic and utility of the structure and application process.

The first two aims are achieved incrementally. The first aim is achieved by identifying structural qualities from the concept maps (Section 7.2), which is a visual representation of the suggested relationships, and formulating investigation lines of enquiry (ILEs) based thereon (Section 7.3). The second aim is achieved by revisiting the typical high-level application process followed in the TTF literature, considering the nature of the relationships between the evaluation concepts and specifying an application process based thereon (Section 7.4). The third aim is achieved by an ex-post review of the ILEs and the specified application process (Section 7.5).

7.2. Identifying concept map structural qualities

The concept map is a visual representation of all the evaluation concepts and the relationships between them. Even though the SMEs noted the complexity of the concept map, it was decided to maintain the larger concept map as a comprehensive reference to the nature of concept relationships. As discussed in Section 5.7, the concept map also provides a structure from which further development may be achieved. To ensure utility, additional ways of structuring the concept map was explored by analysing trends within the map.

The first observation that emerged from the analysis was the existence of various loops or feedback dynamics between concepts in the map. The most prominent loop was identified as a positive reinforcement feedback loop in which the increased prominence of one concept results in the increased prominence of related concepts and, due to the interrelated nature, further increases the prominence of the original concept. This relationship is true for all the concepts within the loop. One of such examples from the concept map is depicted in Figure 7.1. The more familiar (TTF11) a user is with the system, the more the user will intend to use the system (U4). The intention to use contributes to an actual increase in usage frequency (U3). The more the system is used, the more familiar the user becomes with the system. This logic may be regarded from any starting point in the loop.

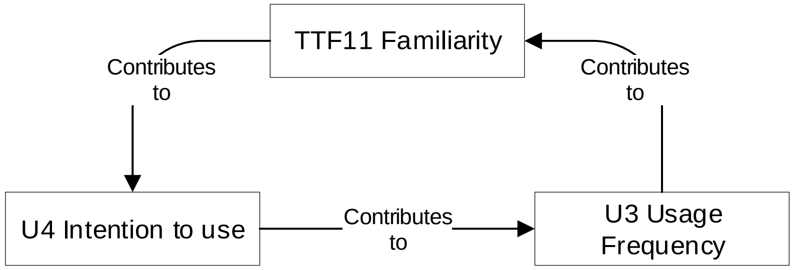


Figure 7.1 Example of a reinforcement loop in the concept map

The second observation that emerged in analysing the concept map was the common occurrence of relationship chains, which we define as the collective set of evaluation concepts that are related to each other. The chain is derived by selecting any starting point within the network and identifying all the successive, related concepts. This may be visually demonstrated by a network of nodes (representing concepts) and directed links (representing relationships) as depicted in Figure 7.2.

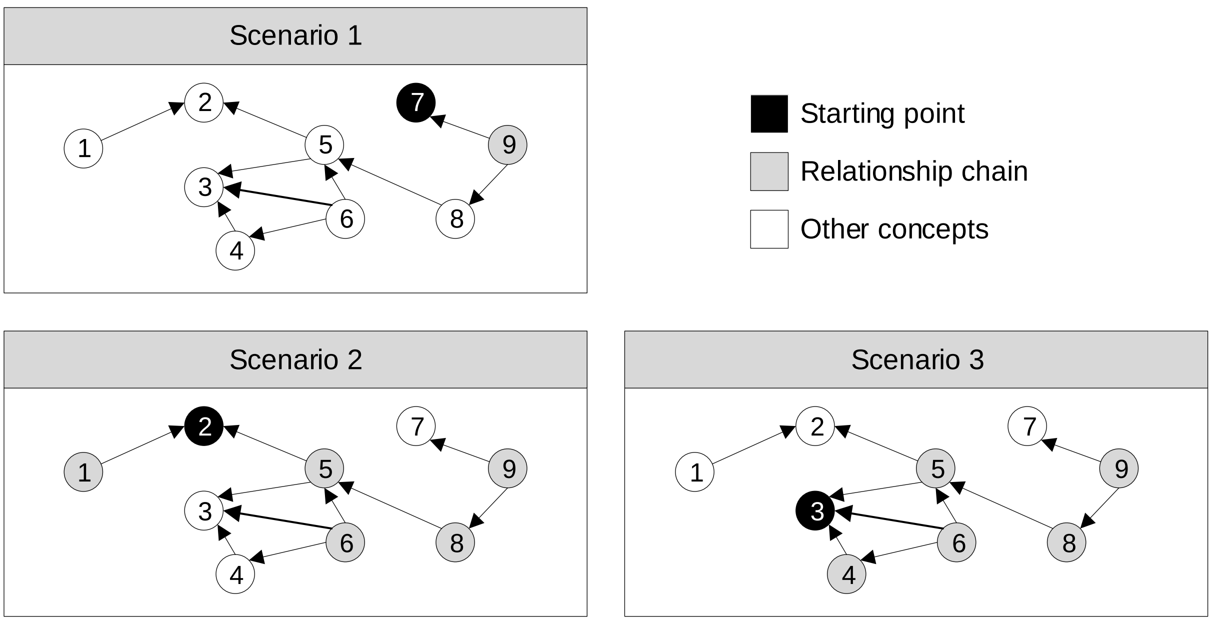


Figure 7.2 Illustration of a relationship chain within an arbitrary network

In the first scenario, node 7 is selected as the starting point and is only directly affected by node 9. Since node 9 is not affected by any further nodes, the relationship chain consists only of nodes 7 and 9. Following the same process in the second scenario, node 2 is selected as the starting point and is directly affected by nodes 1 and 5. Node 5 is affected by nodes 6 and 8, while node 8 is affected by node 9. The relationship chain, starting at node 2, therefore consists of nodes 2, 1, 5, 6, 8 and 9.

In the case of the concept map, it is large in size and there is complexity in its relationships which increases the effort in identifying the relationship chains. The relationships between concepts were established on ATLAS.ti, as discussed in Chapter 5, to develop the concept map. The ATLAS.ti software allows this information to be exported to a data set indicating source concepts, target concepts and relationship type. Considering the available data and the concept of the relationship chain, a method was therefore formulated to automate the process, thereby eliminating the effort to identify these chains.

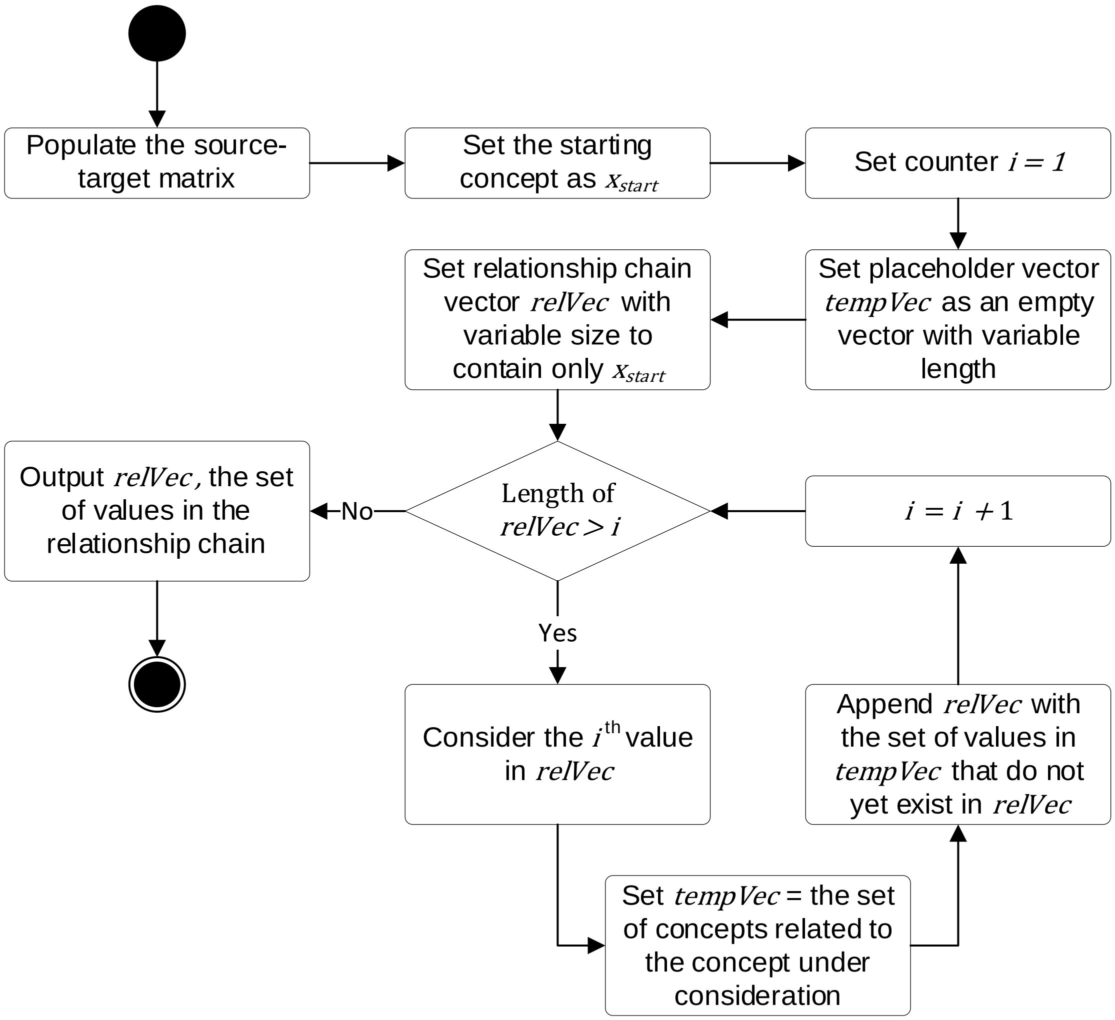


Figure 7.3 Automation process for identifying the relationship chain

Based on the concept map, a source-target matrix is required with a column containing source identifiers and a corresponding column containing the target identifiers. The source-target matrix for the network depicted in Figure 7.2 is tabulated in Table 7.1.

Table 7.1 Source-target matrix for the example arbitrary network

Source	Target
1	2
4	3
5	2
5	3
6	3
6	4
6	5
8	5
9	7
9	8

As formerly discussed, the user selects a starting concept, denoted by x_{start}, from which the relationship chain will be determined. A counter, denoted by i, is used to run through the relevant relationships. Two vectors are used to identify only the relevant relationships for the chain. The vector denoted $templVec$ is populated with all the relationships from any given node in the network and is used to progressively populate $relVec$, the vector containing the relationship chain. To aid the explanation, the process is applied to Scenario 3 depicted in Table 7.2 and tabulated in a stepwise manner to show the values of the different variables throughout the entire process.

Table 7.2 Stepwise application of the automated relationship chain identification process

i	$relVec$	$length(relVec) > i$	Node under observation	$tempVec$	Unique values added to $relVec$
1	{3}	False	3	{4, 5, 6}	{4, 5, 6}
2	{3, 4, 5, 6}	False	4	{6}	{}
3	{3, 4, 5, 6}	False	5	{6, 8}	{8}
4	{3, 4, 5, 6, 8}	False	6	{}	{}
5	{3, 4, 5, 6, 8}	False	8	{9}	{9}
6	{3, 4, 5, 6, 8, 9}	False	9	{}	{}
7	{3, 4, 5, 6, 8, 9}	True	-	-	-

The relationship chains provide a means to simplify the larger concept map, which the SMEs found to be too complex to apply (Section 6.7). These chains therefore provide a basis for the formulation of the robust structure, as set out by the first design cycle aim, which is pursued by formulating investigation lines of enquiry as discussed in the following section.

7.3. Formulation of investigation lines of enquiry

An investigation[7] line of enquiry (ILE) may be defined as a structure which provides a suggested, sequential order of investigation that is formulated by identifying an initial concept to be investigated and sequentially structuring all collective related evaluation concepts (i.e. the relationship chain, discussed in Section 7.2). An ILE therefore incorporates the interrelated nature of the concepts allowing for a more comprehensive understanding of the concept under investigation. It provides a robust structure which is consistent with causal logic, and presents only the necessary evaluation concepts in a simple manner.

Two ILE configurations, linear and radial, were formulated based on the structural qualities identified in the concept map (Section 7.2). A radial ILE configuration is only relevant in the case that a starting point concept is part of a relevant loop; thus, it is of value to investigate the concept with an understanding of the interrelated nature of the relevant concept. Any non-loop alternative starting point concept will therefore result in a linear ILE configuration. These are discussed in the following sections and illustrate the different aspects that form part of the definition.

[7] The term *investigation* is selected as opposed to evaluation as the recommended structure provides a high-level view of potentially relevant concepts and their relationships but requires further work in order to conduct evaluations.

7.3.1. Linear investigation lines of enquiry configuration

Linear ILE configurations are formed by structuring the concepts in a linear fashion which may be from the left to right. This structure may be guided by a set of formulation guidelines, which are applied as an example to the same arbitrary network of nodes depicted in Figure 7.2. Two linear ILEs are formulated in Figure 7.4 by selecting two nodes (node 3 and node 5) as starting points for investigation.

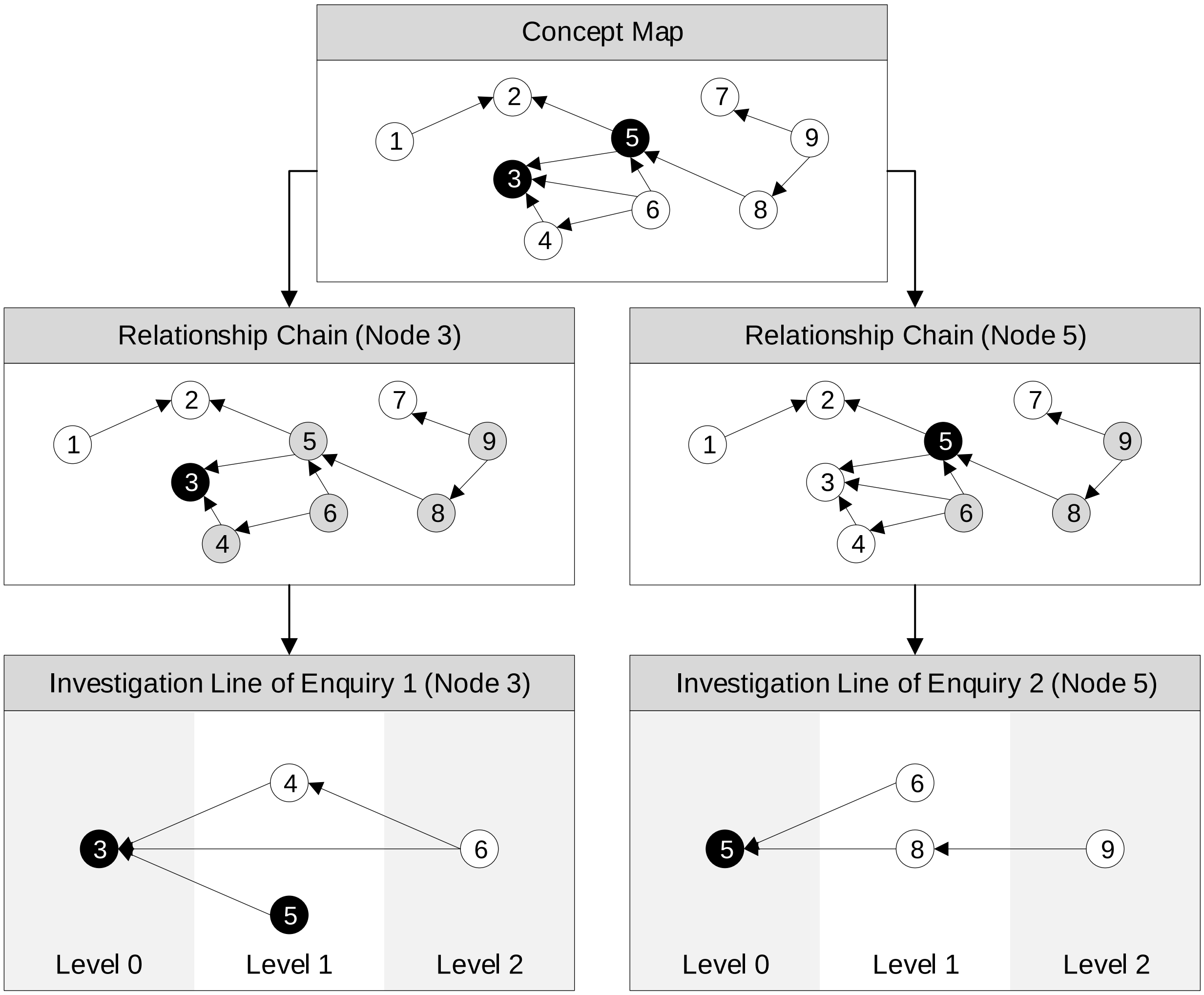


Figure 7.4 Example of formulating linear ILE

The set of guidelines described in Table 7.3, were defined based on the researcher's interpretation to standardise the approach for formulating linear ILEs and are demonstrated with relation to the examples depicted in Figure 7.4. These guidelines aim to standardise the arrangement of the ILE based on the proximity of concepts to the selected starting concept.

Table 7.3 Guidelines for formulating linear ILE

Guidelines	Description	Application to example
Guideline 1: Structure from left to right based on linkages	The concepts should be structured such that it is easily investigated from left to right and top to bottom. The order of concepts in the ILE from left to right should be structured at different levels which reflect the maximum possible number of links from the starting point.	In the case of the ILE 2, node 6 and 8 are directly linked to the starting node and therefore one level away. Node 9 however is two links away from the starting node and therefore positioned at level two. For ILE 1, the same logic is applied. It can be seen however that node 6 is directly and indirectly related to the starting node. Since the maximum possible number of links from the starting node is 2 (Link 1 with node 4 and link 2 with node 3), node 6 is positioned at level two
Guideline 2: Eliminate duplicate investigation effort for multiple starting points	Typically, a number of different starting points will be chosen for investigation, and therefore require multiple ILEs to be formulated. Since the concept map contains multiple relationships between concepts, it will likely result in multiple selected starting points and therefore multiple ILEs. If any of the selected starting point concepts are present while formulating the ILE, no further concepts related to that concept should be investigated as part of the ILE in order to eliminate duplication of investigation effort.	In the first level of ILE 1 where none of the nodes related to node 5 follows on ILE 1 since node 5 is the starting point for ILE 2.

In the following section, the radial ILEs are discussed.

7.3.2. Radial investigation lines of enquiry configuration

As previously stated, radial ILE configurations are formulated when the starting point for an ILE forms part of a relevant loop. An arbitrary example containing a loop is depicted in Figure 7.5 to aid the discussion of the approach for formulating radial ILE configurations.

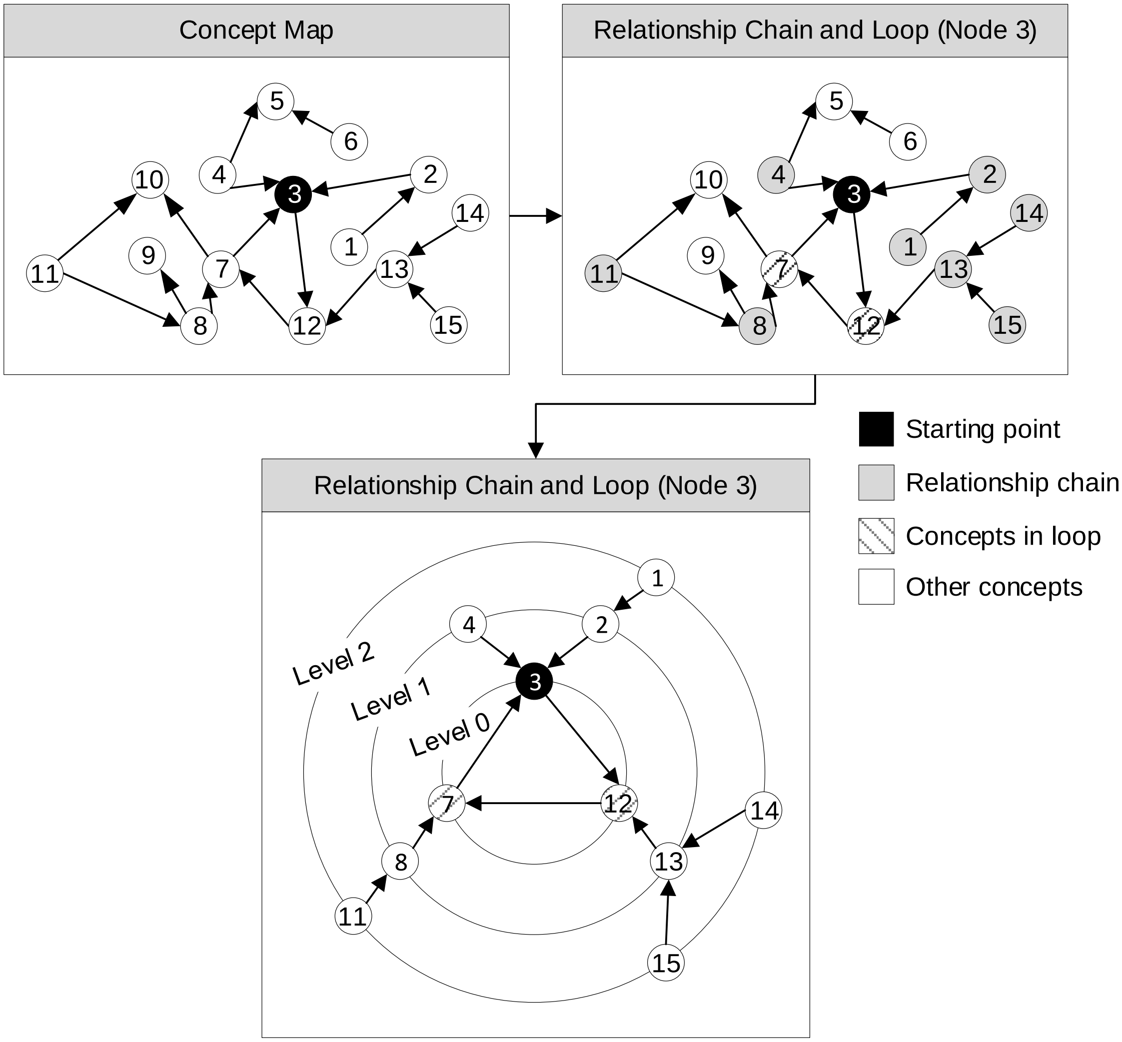


Figure 7.5 Example of a radial ILE

Similar to the linear ILE configurations, a set of formulation guidelines was defined to guide the development of radial ILEs. These are described in Table 7.4 and demonstrated with relation to the example in Figure 7.5.

Table 7.4 Guidelines for formulating radial ILE

Guidelines	Description	Application to example
Guideline 1: Concepts part of the loop form centre of ILE	The entire loop associated with the starting point is placed at the centre and the subsequent investigation levels are plotted concentrically.	Nodes 3, 7 and 12 are at the centre of the ILE, forming part of level 0.
Guideline 2: Subsequent levels are determined by maximum linkages	Similar to the linear configurations, the level at which a concept is positioned is determined by the maximum possible number of linkages from the level 0 concepts.	Although node 3 is the starting point, node 13 is placed on level 1 since it is directly related to node 12, which forms part of the loop. Nodes 14 and 15 are placed on level 2 as the maximum possible of links away from the level 0 nodes are 2 for both cases.

The guidelines discussed in Table 7.3 and Table 7.4 allow for the formulation of both linear and radial ILE configurations based on any starting point part of the concept map as selected by an investigator. The ILEs also provide multiple levels which provide guidance in the order of investigation. Further specifications of the ILEs was omitted based on the feedback from SMEs that the importance of concepts will differ dependent on the application environment (Sections 6.4-6.6). The ILEs therefore provide enough structure to guide the investigation process but enough flexibility for investigators to approach it based on their needs.

Having formulated the robust structure which is consistent with the causal logic and presented in a simple manner with only the necessary evaluation concepts, the process of applying the structure is discussed in the following section.

7.4. Specification of the application process

Different aspects of this study were revisited to establish how the ILEs may be applied as part of the interactive tool. As discussed in Chapter 4, a typical high-level process is followed in the studies as depicted in Figure 7.6. In line with the TTF theory, the researchers identify descriptive factors of the tasks conducted, technology utilised and, in certain studies, the individuals that use the technology. The factors are described at a level which best supports the study objectives and are used to provide context, understand the configuration, and interpret the findings rather than being explicitly incorporated in the data analysis. The following phases consist of the collection of data for the set of TTF concepts under investigation by the researchers, the analysis of the data and the interpretation of the results within the context of the study objectives.

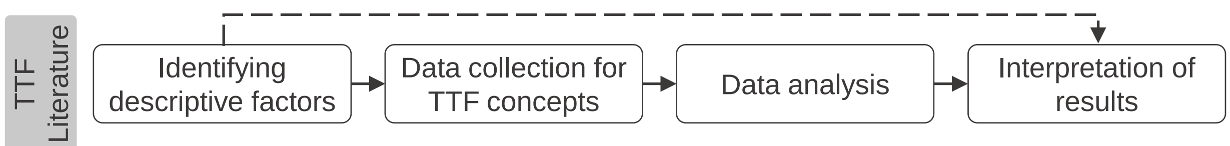


Figure 7.6 High-level process followed in TTF literature

The aim of this study differ from the studies included in the review and does not include a statistical analysis of any concepts; rather, the interactive tool incorporates the TTF concepts to provide information which may be used to support evaluations either in the establishment of or during the evaluation process. The former process identified in literature was therefore used to inform the formulation of the high-level process for applying of the ILEs, consisting of three major phases comprising a number of individual steps, depicted in Figure 7.7.

The first phase involves an initialisation of the information required to formulate and interpret the ILEs. In the second phase, the ILEs are explored through an investigation of the various concepts within each ILEs and identifying pertinent ones. The final phase involves, using insights from the ILEs and the initialisation information to inform the evaluation.

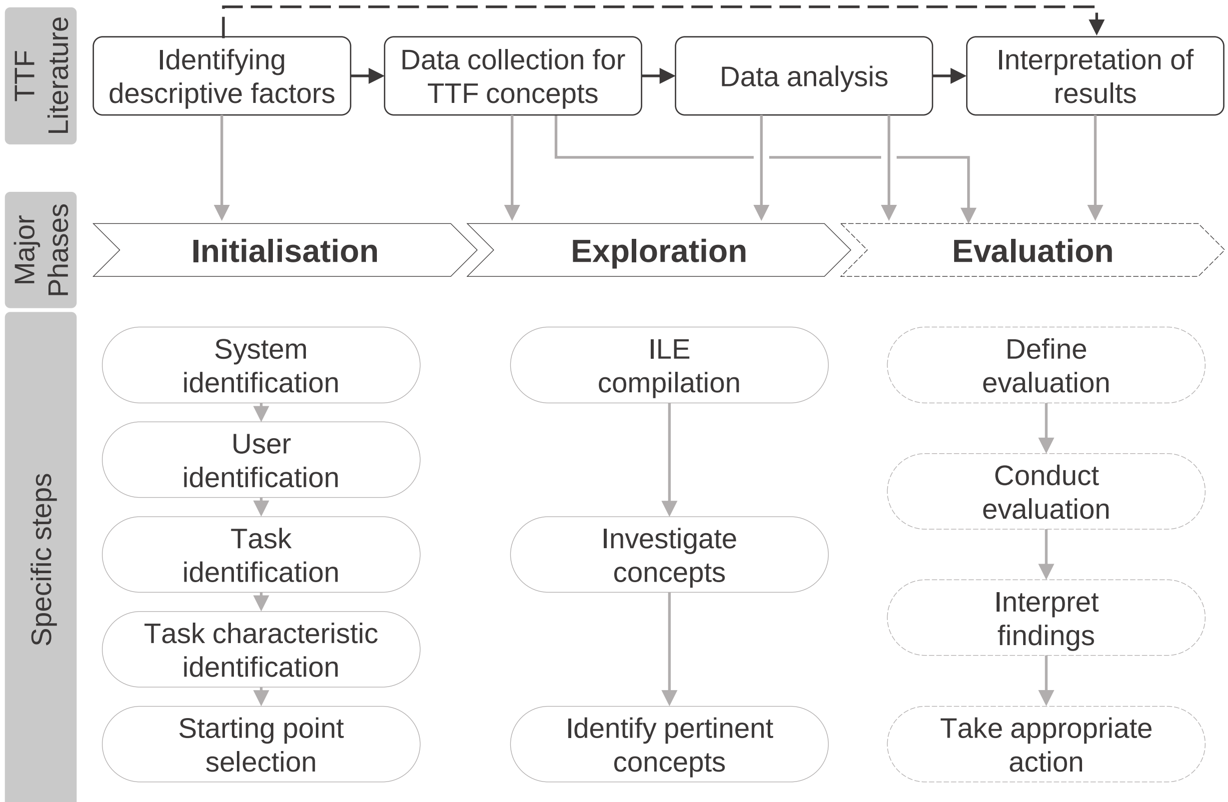


Figure 7.7 High-level application process of the investigation lines of enquiry based off process followed in TTF literature

In the following sections, these three phases are discussed along with the steps that form part of each phase.

7.4.1. Initialisation of investigation lines of enquiry

The first major phase consists of identifying relevant descriptive factors which provides clarity to investigators of what is investigated; providing context for interpreting the findings; and informs what needs to be considered in the following phase and with what priority. The descriptive factors are shown in Table 7.5, categorised according to the three former intentions.

Table 7.5 Descriptive factors considered as part of the interactive tool

Category	Descriptive factors	Questions
Clarity of what & context for interpreting	Description of system	What system is being investigated? What is the purpose of the system?
	Description of the users	Which system users are considered for the investigation and how do they fit in?
Initialisation of ILEs	Description of tasks	What type of tasks performed on the system is considered? Describe the tasks performed by users of the system.
	Description of task characteristics	Which of the task characteristics that form part of the evaluation concept inventory are applicable/prominent in the tasks?

The following step requires that the investigator select a concept or set of evaluation concepts of interest for investigation, from which the ILEs may be compiled. This may be done by selecting concepts based on predefined evaluation objectives, exploring multiple concepts, or selecting appropriate concepts based on the complete set of evaluation concepts and their descriptions. These starting points provide the final required information for the exploration of the ILEs, which is discussed in the following section.

7.4.2. Exploration of the investigation lines of enquiry

Based on the information from the initialisation phase, the relevant ILE's may be compiled following the process discussed in Section 7.3. The ILEs provide a provide a robust structure which guides the exploration of pertinent concepts based on their relationship with other concepts.

To determine how the ILEs may be applied and concepts investigated, the complete set of evaluation concepts and relationships between concepts were considered and two categories of concepts were identified. These categories are depicted in Figure 7.8.

Figure 7.8 Two concept categories for ILEs

The first category, *descriptive concepts,* is made up of concepts which may be used to *describe* different socio-technical facets of a system which influence the overall functioning of the system, and therefore directly applicable for evaluation purposes. When these concepts are present in the relationship chain, they provide additional concepts that may contribute to the initial identified concept of interest and should therefore also be investigated to determine the relevance.

This category is demonstrated by an example in which the ease of access to required information (*TTF2 Accessibility*) is of interest and therefore selected as a starting point for investigation. The resulting abridged two-level ILE, depicted in Figure 7.9, reveals that three additional concepts contribute to accessibility and should also be investigated. Firstly, if users do not have authorisation to the system then the required information will not be accessible (*TTF4 Authorisation)*. Additionally, if the information required is dependent on data from another system, the systems should be able to efficiently work together and share information (*AC8 Interoperability).* Finally, for information to be accessible when required, the system needs to be functional and therefore consistent in its uptime (*TTF25 Systems reliability).*

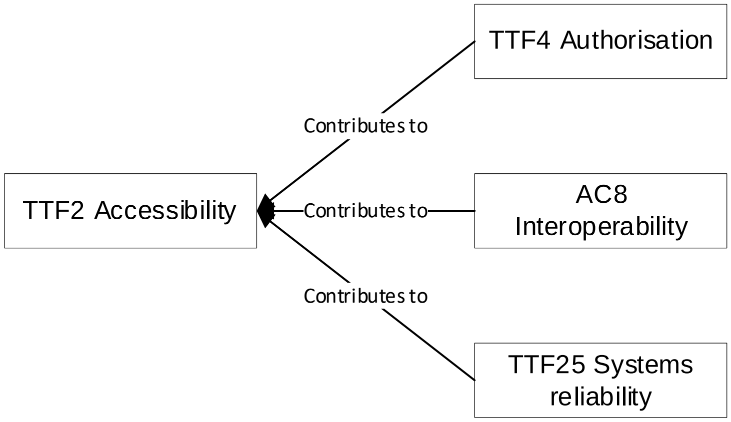


Figure 7.9 Abridged two level ILE with accessibility as a starting point

The second concept category is identified as *auxiliary concepts;* it consists of the concepts that were identified in Chapter 4 as part of *Task Characteristics*, and form part of the evaluation concept inventory with the *TaC* identifier. The descriptions of these concepts were found to be different from the former category of concepts in that it does not provide direct insight about aspects of the system under investigation. Rather, these contribute to a better understanding of the descriptive concepts based on the concept description and type of relationship.

The relationships associated with these concepts consist of two types, *prioritises* and *is a consideration for*. Where the *prioritises* relationship is present, it may be considered that, *if the [auxiliary concept] is prominent then all the related concepts are of greater importance*. This may be demonstrated by the relationship extracted from the concept map, depicted in Figure 7.10. If the nature of tasks that users are expected to perform is difficult (*TaC2 Difficulty*) then the availability of training for users (*TTF29 Training availability*) is considered to be of greater importance than when the task is simple.

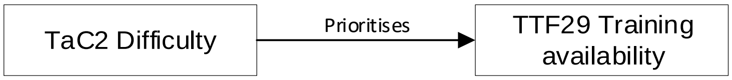


Figure 7.10 Example of priority relationships

As stated in Section 7.4.1, the relevant task characteristics are identified during the initialisation of the ILEs; thus, only those identified should be displayed as part of the ILEs. Furthermore, since these auxiliary concepts are identified upfront and do not require further investigation, an alternative depiction is used to ensure that only concepts which require investigation are displayed. Using the example depicted in Figure 7.10, this alternative state is depicted in where the identification of the descriptive concept being a priority may be seen due to the subscript indicating the auxiliary concept (*TaC2 Difficulty*).

Figure 7.11 Alternative depiction of prioritised concepts

The second type of relationship, *is a consideration for*, is only relevant to the concepts *TaC3 Task Frequency* and *TaC7 Non-routineness* and provides a way to interpret the related concepts. This may be demonstrated by the example extracted from the concept map, depicted in Figure 7.12. In the evaluation of the system, investigators may find that there is a low frequency of system usage. Considering how frequently tasks are actually meant to be performed (*TaC3 Task frequency*) provides insight into whether the system is underutilised – in the case that the task frequency is high, or, that, although the usage is low, the tasks are not performed often and therefore there is no utilisation problem.

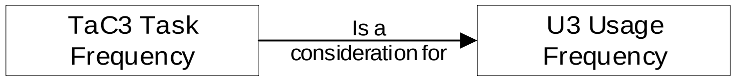


Figure 7.12 Example where a concept is a consideration for another

Based on the description of each concept and an understanding of the concept categories, as well as an investigation of related concepts, it has been demonstrated the ILE should be used to identify pertinent concepts to inform further evaluation. The relevance of a concept is considered context-bound, as informed by both the DSR paradigm and the realistic evaluation; therefore, investigators should define specific criteria for relevance based on both the context of the system under evaluation as well as the evaluation context.

The sequential structure of the ILEs (Section 7.3) as well as the understanding of how descriptive and auxiliary concepts, along with their respective relationships, provide a reference for investigating the concepts and determining their pertinence. These elements are therefore synthesised and summarised in Table 7.6 to guide the exploration of the ILEs. An example of how these guidelines are applied is provided in Chapter 9 with the presentation of the final interactive tool.

Table 7.6 Guidelines for exploring investigation lines of enquiry

Exploration guideline	Explanation
Exploration guideline 1: Investigate concept based on the concept description and determine the relevance of the concept based on system or evaluation context	The set of evaluation concepts included in the inventory all provide important considerations for evaluation. The presence of a concept in an ILE suggests its importance based on the selection of a starting concept. The concept description should aid the understanding of what a concept refers to.
Exploration guideline 2: Where applicable, review the additional considerations provided by the auxiliary concepts	The presence of the auxiliary concepts identified in the initialisation phase prioritises certain descriptive concepts or provides a way to interpret these concepts. Specific attention should be given to concepts which are related to the applicable auxiliary concepts.
Exploration guideline 3: Determine concept relevance for further evaluation based on system or evaluation context	The relevance of concepts should be determined by the investigator based on the specific system, its context, and the evaluation context. If the concept description is found to be insufficient to identify the relevance thereof, the investigator should use the description to guide the identification of more detailed measures that may be applied to determine the relevance.
Exploration guideline 4: If a concept is not found to be pertinent, further related concepts do not need to be investigated	The ILEs provide a structured approach to identify consider concepts that are related to each other, and consequently may influence the state of the system. Therefore, if a concept is found to be irrelevant then the concepts that influence the concept under consideration do not need further investigation.

Exploration guideline	Explanation
Exploration guideline 5: Consider related descriptive concepts and the type of relationship	The relationships between concepts may provide a greater understanding of factors that influence the functioning of the system. The influence of related concepts should be considered based on the type of relationship and investigation of the concepts.
Exploration guideline 6: Use the concept relationships and ILE structure to guide the order of investigation.	The ILEs are structured sequentially based on the relationships between concepts. These may be used as a reference for ordering the investigation.

The insights obtained from investigating the concepts and identifying those relevant to the system may be used along with the descriptive information identified in the initialisation phase to inform further evaluation, as discussed in the following section.

7.4.3. Evaluation based on the insights from the investigation lines of enquiry

The formulation and execution of the evaluation as well the interpretation of the findings falls outside the scope of this study. Four high-level steps based on the insights gained from the review of Monitoring and Evaluation (Chapter 3) are however provided to discuss how the insights from the ILEs may be incorporated to support each step. These steps and the corresponding contributions of the ILEs are presented in

Table 7.7 Contribution of the ILEs to support evaluation

Evaluation step	Contribution of the ILEs
Define the evaluation	The descriptive information from the initialisation phase provides importance information to understand the context of the evaluation. The exploration phase of the ILEs provide insight into a set of evaluation concepts that were identified as being relevant for further evaluation. These may be used to focus the evaluation in order to inform decision making around these concepts.
Conduct the evaluation	The ILEs provide a more comprehensive understanding of how different socio-technical aspects of the systems are related. This may allow evaluators to take appropriate action by adding additional aspects to the evaluation or refining existing measures for the aspects under evaluation to best reflect the real-world scenario.
Interpret findings	The descriptive information aids the interpretation of the findings by providing contextual information. This is important as the specific outcomes of the evaluation is seen to be context-bound and should therefore be interpreted based on the context. The information allows the findings to be phrased in terms of *what works, for whom, under what conditions* - in line with the realist evaluation paradigm.

Evaluation step	Contribution of the ILEs
Take appropriate action	The ILEs provide a comprehensive insight into what concepts may additionally be focused on to improve potentially problematic areas as well as what other concepts may be affected when action is taken. The responsive concept map in the interactive tool may also be used to identify these concepts or other concepts of interest. The findings of the evaluation may highlight additional areas of interest for investigation and guide the investigator to consider the ILEs in different areas of system usage, different users, or additional concepts to consider.

Having formulated the investigation lines of enquiry (Section 7.3) and specified the subsequent application process in this section, which respectively achieve the first two design cycle aims, an ex-post review was conducted to confirm the logic and utility of these. This is discussed in the following section.

7.5. Ex-post review: Investigation lines of enquiry and application process

The four SMEs interviewed, as discussed in Chapter 6, were reconsulted to review the formulation and application process of the ILEs and thereby achieve the third design cycle aim. The review consisted of a virtual presentation over Zoom which consisted of two parts. Firstly, an overview was given of the study objectives, the previous work evaluated, and the subsequent changes made based on the insights from the interviews to ensure that the context is understood. Secondly, the role of the ILEs, their formulation and the application process were presented, and the SMEs were asked to 1) review the logic, 2) provide feedback on the utility.

The SMEs confirmed the logic of the ILES and did not identify any specific errors in the suggested formulation or application process. The M&E expert observed they found the ILEs to be particularly useful as it helps to guide the way of thinking around what concepts to investigate and in what order. The TTF experts remarked that both the mapping out of concept relationships and further structuring thereof in the form of the ILEs is a novel application of the TTF theory and a valuable contribution in the field.

The interviewee involved in the development of CBHIS confirmed that the process described in Section 7.4 is sufficient to guide the application of the ILEs. They did however note that, due to the size and complexity of the concept map, the process of compiling the ILEs may result in errors and may be unnecessarily time consuming, especially where multiple concepts are considered as starting points.

Finally, the SMEs suggested that individual ILEs should be restricted to a number of levels (Section 7.3.1) to ensure that it is easy to read and that investigators are not visually overwhelmed with a large number of concepts. This may be achieved by following the same logic applied when multiple starting points are selected (Section 7.3.1), i.e., selecting concepts to create additional ILEs from rather than adding the remaining concepts in additional levels.

7.6. Concluding remarks: Chapter 7

In this chapter, the fifth design cycle iteration was completed; it consists of a *develop* and *evaluate* component to meet the design cycle aims, as depicted in Figure 7.13. Structural qualities of the concept map were identified and used to inform the formulation of a robust structure, specifically the ILEs, to achieve the first design cycle aim as well as FR3 of the tool development requirements.

The ILEs are structures which provide a suggested, sequential order of investigation that is formulated by identifying an initial concept to be investigated and sequentially structuring all collective, related evaluation concepts. The ILEs incorporate the interrelated nature of the concepts while providing a generic approach to simplify the concept map and logically guiding the investigation process (see footnote 7 on page 90). Furthermore, a process was formulated to guide the application of the ILEs and aid its utility in achieving the study objectives, thereby achieving the second design cycle aim.

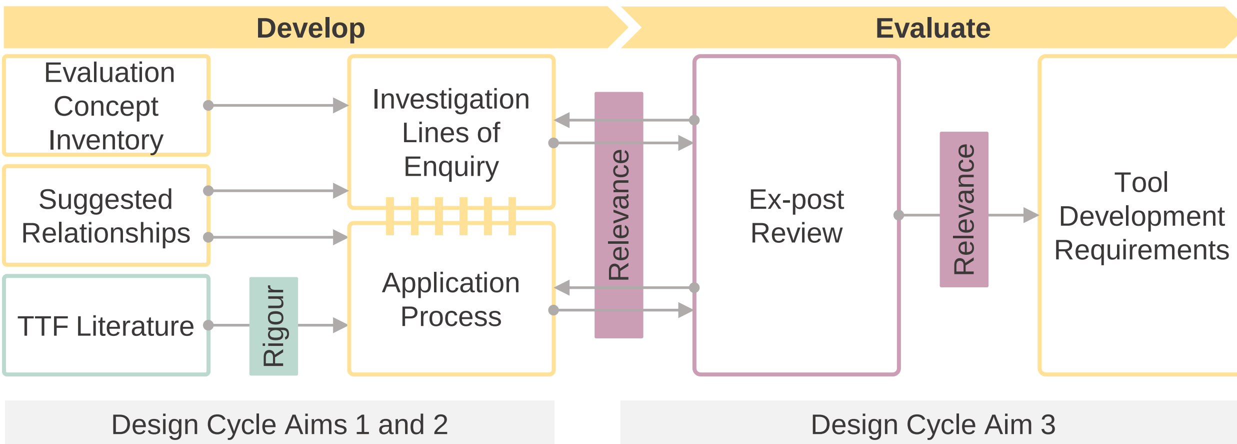


Figure 7.13 Completion of the fifth design cycle iteration

The ILEs and the application process were reviewed by the SMEs who confirmed the logic and the utility thereof. Further insights obtained from the ex-post review are used to formulate two additional tool development requirements, which are categorised as *User Requirements* (UR), that contribute to the utility of the interactive tool and need to be met in the final design cycle iteration. These requirements are presented in Table 7.8.

Table 7.8 User requirements added to the tool development requirements

Requirement category	ID	Requirement
User requirements	UR1	The compilation of the ILEs should be in automated in the final tool by allowing the interactive tool users to provide the initialisation information electronically and subsequently presenting the resulting ILEs in an appropriate manner.
	UR2	Each individual ILE should be restricted in the number of levels that is displayed by splitting the ILE at specific concepts and creating an additional ILE based on the concept.

This chapter concludes the third phase of the research, which is aimed at establishing the various tool components. The three tool components are depicted in Figure 7.14 and the presentation order from left to right reflects the order in which these were formulated in the research – with each tool building on the previous components.

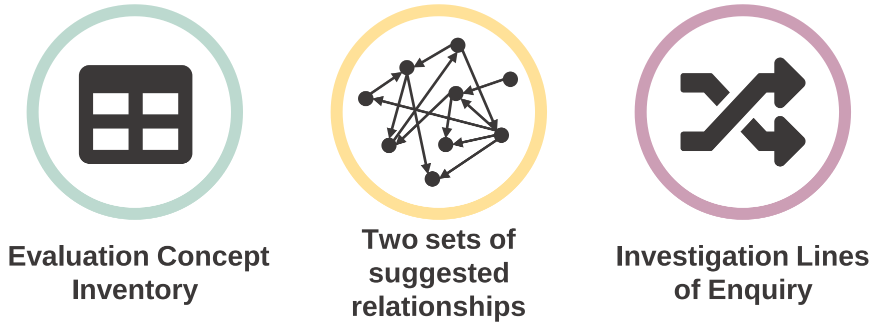


Figure 7.14 Overview of the interactive tool components

The first component is the evaluation concept inventory which provides a set of evaluation concepts initially identified in literature and thereafter refined, supplemented and contextualised in multiple iterations to reinforce relevance and rigour. The final set of evaluation concepts may be found in APPENDIX C.

Similarly, the second component consists of the suggested relationships between the evaluation concepts based on the two primary user-system related. These relationships were identified as part of the data analysis in the case study (Chapter 5), evaluated by SMEs and appropriately adapted based on the evaluation findings to reinforce the relevance and rigour thereof (Chapter 6). The final set of relationships between the evaluation concepts may be found in APPENDIX D.

These two former components provide the foundation for the formulation of the ILEs and its application process. The ILEs merely structure the two former components in an appropriate manner and the utility thereof was confirmed by the SMEs (Chapter 7).

These components provide the basis for the interactive tool to support the evaluation of CBHIS and to this end are consolidated to design and develop the final interactive tool. The design and development process is discussed in the following chapter.

Chapter 8. Design and development of the interactive tool

8.1. Introduction

In the previous chapter, the final components of the interactive tool were established. In this chapter, the completion of the sixth and final design cycle iteration is discussed which aimed to consolidate the various tool components into an interactive tool. The high-level process depicted in Figure 8.1 was followed to achieve this aim.

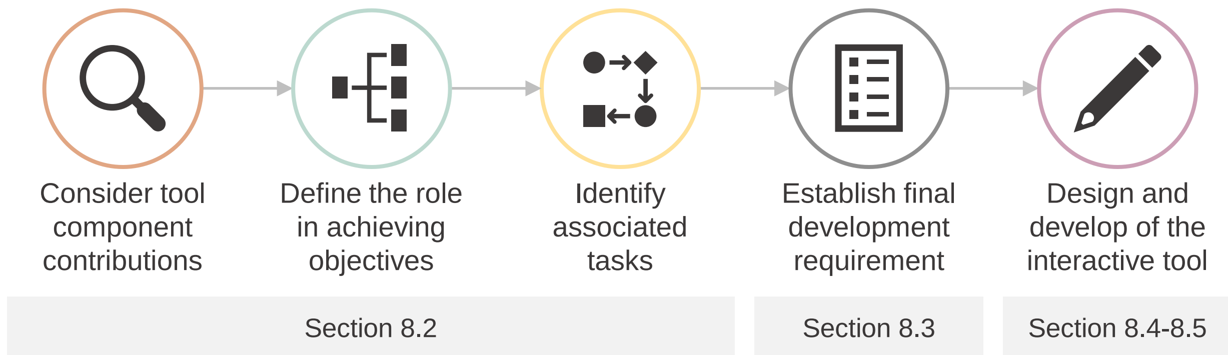


Figure 8.1 Process for the final development iteration of the interactive tool

The execution and findings of each step in the process is discussed in the following sections.

8.2. Formulation of the interactive tool usage process

In this section, the execution of the first three steps of the final development iteration is discussed and are summarised in Table 8.1. For each of the interactive tool components, their individual contributions are considered along with a description of its role in supporting the evaluation of CBHIS. Although the three components are progressively built on each other, their unique contributions to support evaluation warrants their individual inclusion in the interactive tool.

The interactive tool should operationalise these components such as to effectively enable the contribution of each component to support the evaluation of CBHIS. This is pursued by identifying a set of generic tasks that may be performed by the tool users to extract this former value. It is important to note that the tasks described in Table 8.1 reflect only the direct interaction with the user and the interactive tool. These specific tasks inform what the interactive tool should be functionally capable of achieving while the broader set of tasks performed by tool users in the evaluation context (discussed in Chapter 9) inform how these elements should be presented.

Table 8.1 Identifying how tool components support the evaluation of CBHIS

Tool component	Tool component contribution	Role in supporting the evaluation of CBHIS	Tasks
Evaluation concept inventory	Provides a tangible set of refined and contextualised evaluation concepts.	Focuses what concepts to consider for evaluation, providing an overview of what each concept is. This may be used to further develop specific evaluation protocols.	1. View the set of evaluation concepts 2. Consider individual concepts
Suggested relationships	Provides a set of relationships between the evaluation concepts.	The relationships provide a means to consider which concepts might affect, or be affected by, other concepts to guide further evaluation.	1. Identify a set of related concepts 2. Consider the relationships between a set of evaluation concepts 3. Perform the two former tasks by considering: a. the entire concept map, or b. only selected concepts
Investigation lines of enquiry	Provides a logical structure in which to consider the evaluation concept inventory concepts and their relationships.	The simple, robust structure provides a means to guide the evaluation by presenting concepts, their relationships and other important information for the tool users to make informed decisions surrounding the evaluation.	1. Identify the set of descriptive factors about the system, users, and tasks 2. Select starting point concepts 3. Consider the concepts, relationships, and structure of the ILEs[8]

Having identified the tasks that the interactive tool should operationalise, the architecture of the interactive tool was designed and is discussed in the following section.

8.3. Interactive tool architecture

The architecture of the interactive tool was designed using the logic of the input-process-output model which is widely used in the design of software (Goel, 2010). The model identifies the *inputs* that are used by the interactive tool to produce specific *outputs* through a back-end *process*. The input-process-output architecture of the entire interactive tool is depicted in Figure 8.2.

[8] The user-tool related tasks for the ILEs are extracted from the detailed ILE application guidance discussed in Section 7.4.

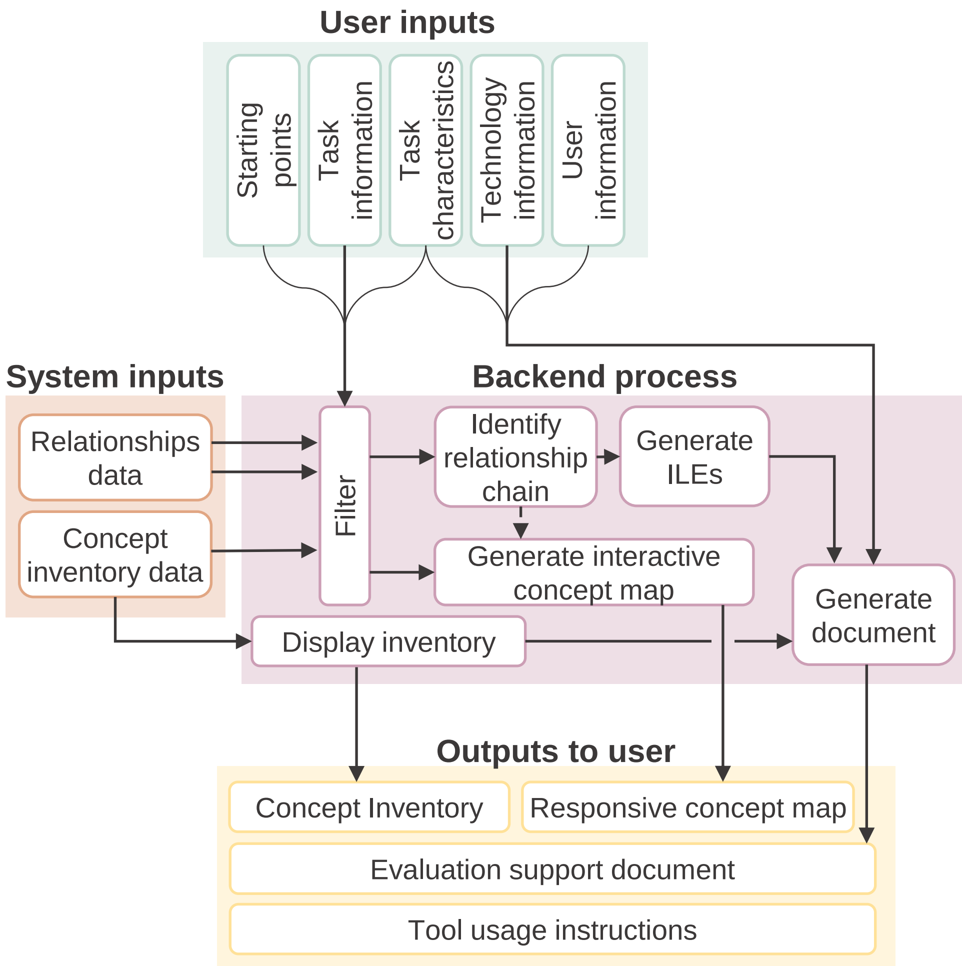


Figure 8.2 Input-process-output architecture of the interactive tool

The interactive tool considers two types of inputs. The *user inputs* consist of the various information required to both generate the interactive map, displaying only the relevant information, to initialise the ILEs and to provide relevant descriptive information to aid the process. The *system inputs* consist of the concept inventory data as well as the associated relationship data.

As discussed in Section 5.5, the ATLAS.ti software was used to develop the concept maps. The software was used to export the concept map information into comma-separated values and further manipulated for effective use in the interactive tool.

Based on the discussion in Section 8.2 of the contribution, role and tasks related to each of the interactive tool components, four primary outputs were identified as valuable for the user of the interactive tool, three of which are regarded as *functional outputs* and one as a *supportive output*. The supportive output is the *tool usage instructions*, which provides a concise description of the various tool components, their value and how they may be used.

The *concept inventory* provides an overview of the set of evaluation concepts with their respective descriptions that may be used as a reference in the other parts of the interactive tool. This simply requires that the concept inventory data is displayed in an appropriate manner.

The *responsive concept map* provides users with a means to consider which concepts might affect, or be affected by, other concepts. The concept map should be developed in an interactive way such as to allow the exploration of only that which is needed. Users should therefore be able to view either of the two concept maps, focus on specific concepts and view the desired types of relationships. This is achieved by generating the concept map based on the concept inventory and the relevant concept relationships data and appropriately filtering this based on the user inputs.

Although the ILEs provide a structure by which an evaluation may be logically guided, the actual application of the ILEs requires the further development of context-appropriate measures that align with the objectives and needs of the evaluation. Furthermore, the evaluation itself would take place after the interaction with the interactive tool and the ILEs specifically. Therefore, the interactive tool ILEs and other related information should be combined into a single *evaluation support document* that 1) provides sufficient guidance to apply the ILEs in the evaluation context and 2) can be converted into a physical format such that it may be easily applied and referenced at a future point within the evaluation. The interactive tool should therefore utilise the user input data to *filter* the relevant data, *identify the relationship chains* based on the selection of starting points by the user to then *generate* the ILEs. The ILEs should be packaged along with the concept inventory and relevant user input information *to generate the document*.

This architecture of the interactive tool provides the basis for final development of the interactive tool. In the following section, the final tool development requirements are established to effectively assist the operationalisation of the architecture into the interactive tool.

8.4. Establish final tool development requirements

The tool development requirements introduced in Chapter 3 and updated in Chapter 6 and Chapter 7 aim to assist the development such that the interactive tool effectively achieves the aim of this study. In this section, the final set of tool development requirements is established.

The three tool components were found to meet seven out of the eight initial tool development requirements; the fulfilment of these requirements is discussed in Chapter 9. The remaining requirement is concerned with *implementation guidance*, specifically, that the interactive tool should provide sufficient implementation guidance to ensure its utility while not over-constraining the interactive tool.

To ensure the utility of the interactive tool's user interface, a set of usability heuristics formulated by Nielsen and Molich (1994; 1990), which may be considered as general principles for user interface design (J. Nielsen, 2005), was selected and added to the tool development requirements. These are categorised as User Interface Requirements (UIR). The final set of tool development requirements to be met in the development of the final interactive tool are described in Table 8.2.

Table 8.2 Final tool development requirements (J. Nielsen & Molich, 1990)

Category	ID	Requirement	Description
General requirements	FR3	Implementation guidance	The interactive tool should provide sufficient implementation guidance to ensure its utility while not over-constraining the interactive tool.
User interface requirements	UIR1	Match between system and the real world	The system should speak the users' language, with words, phrases, and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order.
	UIR2	Consistency and standards	Users should not have to wonder whether different words, situations, or actions mean the same thing.
	UIR3	Error prevention	A careful design which prevents a problem from occurring in the first place is preferred above error dialogs. Either eliminate error-prone conditions or check for them and present users with a confirmation option before they commit to the action.
	UIR4	Recognition rather than recall	Minimize the user's memory load by making objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.
	UIR5	Aesthetic and minimalist design	Dialogues should not contain irrelevant or rarely needed information. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.
	UIR6	Help and documentation	Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search in a manner focused on the user's task, list concrete steps to be carried out, and not be too large.

Having designed the architecture of the interactive tool and established the final tool development requirements, the interactive tool was developed in an appropriate coding language as discussed in the following section.

8.5. Development of the interactive tool

The R coding language was selected for the development of the interactive tool due to several reasons. Firstly, R was found to have the capability to execute the interactive tool design and easily incorporate various relevant packages, which eliminates the need to create something that already exists. Secondly R has a large number of online resources available which provides guidance and support for both the R coding language and the packages. The primary set of packages in the interactive tool is summarised in Table 8.3. Finally, the author has experience with the software, which allows for easier implementation of the interactive tool design.

Table 8.3 R plugins used in the development of the interactive tool

R Package	Usage in the interactive tool
Shiny	The package allows interactive applications to be easily built within the RStudio integrated development environment and allow the incorporation of other packages. The Shiny package therefore provided the basis for the development of the interactive tool and its functionality is expanded with the other packages described in this table
shinydashboard	The package was used to develop a dashboard style interface that allows ease of switching between different parts of the interactive tool.
networkD3	The package generates interactive network maps based on the specification of nodes and links. This was used to generate the responsive concept map by manipulating the study data into the appropriate format.
shinyjs	The networkD3 package was found to be limiting in the output it generates. The shinyjs package allows for JavaScript to be used within an R environment. Since networkD3 creates a JavaScript output, the shinyjs package allowed the output to be appropriately adapted for the purposes of this study.
DiagrammeR	The package allows flowcharts to be created through specification of nodes and edges. The package also provides a large number of elements that may be manipulated; these were used to display the ILEs by processing the data, parsing it in an appropriate format and exporting the outputs as scalable vector images.

A structured, iterative approach depicted in Figure 8.3, influenced by the DSR approach was formulated to code the interactive tool.

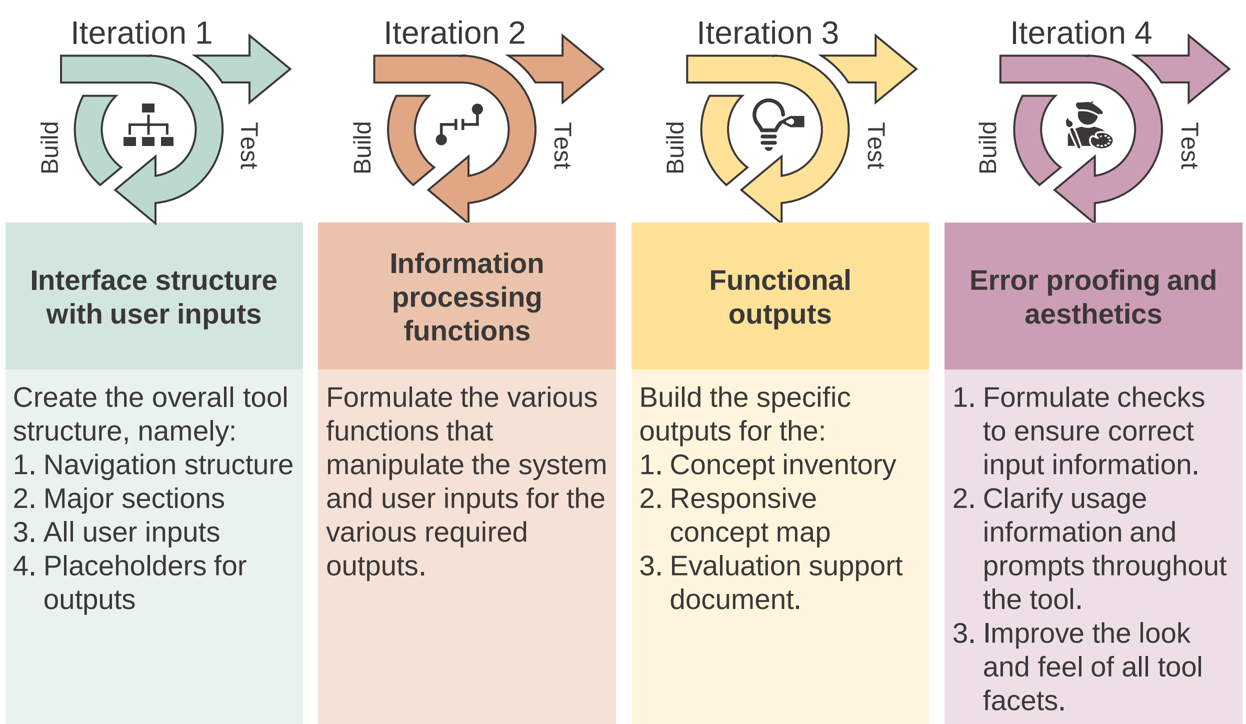


Figure 8.3 Iterative coding process followed to develop the interactive tool

Each iteration consisted of a *build* and *test* phase to ensure complete functionality before further development is pursued. In the case that the *test* phase revealed errors, the appropriate modifications were made and the iteration retested. The content for each iteration was determined by logically grouping aspects of the interactive tool's architecture (Section 8.3) and the final tool development requirements (Section 8.4). Since the various aspects of the interactive tool build on each other, the iterations were sequenced based on the dependence of the other aspects.

8.6. Concluding remarks: Chapter 8

In this chapter, the sixth and final design cycle iteration was completed to consolidate the three tool components into the interactive tool to support the evaluation of CBHIS, as depicted in Figure 8.4. The various tool components established in the previous phase of the study were revisited to identify the contribution of each, and the specific tasks that may be performed to extract value from these components. This was used to design the architecture of the interactive tool and the various components thereof.

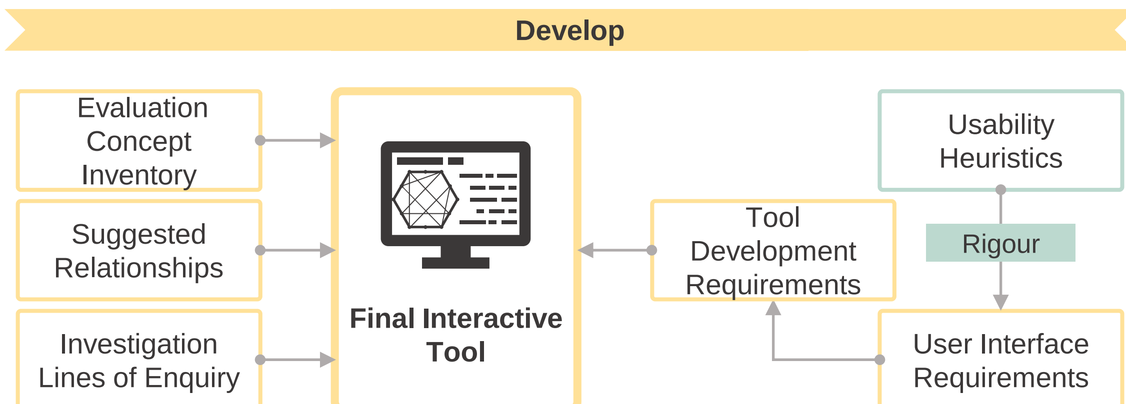


Figure 8.4 Completion of the sixth design cycle iteration

Additional tool development requirements were identified to ensure the usability of the user interface and incorporated in the final development of the interactive tool. The interactive tool was developed using the R coding language along with several packages which provides additional capabilities to easily execute the interactive tool design. The final development of the interactive tool was completed in four iterations with each building on the previous.

The result of the final design cycle iteration discussed in this chapter is the final interactive tool to support the evaluation of CBHIS. The interactive tool is presented in the following chapter along with a demonstration of its functionality to answer the main research question.

Chapter 9. An interactive tool to support the evaluation of clinic-based health information systems

9.1. Introduction

This chapter answers the main research question, namely, *how can the evaluation of clinic-based health information systems be supported by an interactive tool?*

The main research question is answered through the presentation of the final interactive tool to support the evaluation of CBHIS. A summary of the motivations for the interactive tool's development and its intended purpose is provided (Section 9.2). Thereafter, an overview of the development process is provided (Section 9.3). The various components of the final tool are presented, and its contribution explained. A procedure for applying the interactive tool is presented to both assist users in applying the interactive tool as well as to demonstrate the functionality thereof (Section 9.4).

9.2. Motivation and purpose for the interactive tool

CBHIS aim to consolidate information relevant to the PHC environment from various stakeholders across multiple areas of interest, thereby mitigating the problems faced within the health system (English et al., 2011; Rohde et al., 2008; World Health Organization, 2010, 2017b). These systems themselves face a number of socio-technical problems that prevents the effective functioning of these systems (Adebesin et al., 2013; Braa et al., 2007; Heeks, 2006; Nicol et al., 2017; Rohde et al., 2008; South Africa. Department of Health, 2019a; South Africa. Department of Health & CSIR, 2019).

The evaluation of CBHIS allows these socio-technical problem to be identified and mitigated. Furthermore, the evaluation of these systems helps in identifying aspects that work which may be disseminated for general improvements in the system (Ammenwerth et al., 2004; Andargoli et al., 2017; Crepaldi et al., 2018; Neame et al., 2020; Rossi et al., 2018; Sockolow et al., 2012; Yusof et al., 2008). The interactive tool developed in this study aims to support these evaluations by providing adequate information for decision-making purposes. This tool can allow evaluators to explore important aspects related to the system as a preliminary or supplementary step before embarking on an extensive evaluation. The development of the interactive tool was motivated by the conviction that well-functioning CBHIS will contribute to the improvement of the health system and therefore improve the overall quality of care.

Despite the interactive tool's development being motivated by the problems related to CBHIS in South Africa, it's utility need not be limited to this context. The evaluation concepts and relationships are contextualised to suit the PHC environment but, with small adaptations, may provide valuable insights for IS outside this context.

9.3. Summary of the interactive tool development process

The development of the interactive tool is discussed throughout the document. This section provides a summary of the development process.

The development process of the interactive tool is based on the DSR framework and consists of six design cycle iterations. These iterations comprise of evaluation and development components which repeatedly draw insight from the application environment and the knowledge base to ensure the relevance and rigour of the interactive tool and the development process. The relevance of the interactive tool is concerned with the interactive tool being appropriate, applicable, and implementable within the environment. The rigour of the interactive tool is concerned with the interactive tool being grounded in existing knowledge and the research process showing integrity and legitimacy. A number of research methods were incorporated in the design cycles to support the evaluation and development as well as aid the rigour thereof.

The evaluation component of the design cycles aims to appraise the relevance, rigour and utility of the existing tool aspects developed in former design cycles and adapt these aspects accordingly. The development component consists of the formulation, design and building of the interactive tool aspects based on insights gained from the application environment, knowledge base or the evaluation components. The development of the interactive tool based on these insights established the relevance, rigour and utility as part of the development process.

Furthermore, a set of tool development requirements was formulated, and updated throughout the development process, which aimed to assist the development of the interactive tool such that the interactive tool effectively achieves the aim of this study while minimising the constraints; this is to allow for creativity and exploration within the specified bounds. The final set of requirements are presented in Table 9.1, and consists of various requirement categories, namely:

1. *Functional requirements (FR):* specifications that need to be exhibited by the interactive tool that aims to ensure the interactive tool effectively supports evaluation by aligning with Monitoring and Evaluation (M&E) principles and approaches.
2. *Identification requirements (IR):* aims to support the identification of a tangible set of evaluation concepts from the IS domain by guiding the selection of an appropriate theory.
3. *User requirements (UR)*: specifications derived from insights provided by users in the application environment that aim to ensure that the various aspects of the interactive tool is useful for the end users.
4. *User interface requirements (UIR):* specifications derived from established usability heuristics that aim to ensure the utility of the interactive tool's user interface.

Table 9.1 Tool development requirements which guided the overall development process

Requirement Category	Requirement
Functional requirements	FR1 – The interactive tool should use and adapt terminology in a manner consistent with M&E language, specifically that of the realistic evaluation, and should empower users to communicate findings in a manner consistent with "what works, for who and under what conditions".
	FR2 – The interactive tool requires a robust structure which is consistent with the causal logic and presented in a simple manner with only the necessary evaluation concepts.
	FR3 – The interactive tool should provide sufficient implementation guidance to ensure its utility while not over-constraining the interactive tool.
	FR4 – The interactive tool should present concepts and guide the evaluation process to ensure that the findings are able to be communicated in an explanatory manner.

Requirement Category	Requirement
Identification requirements	IR1 – The theory should align with the overall emphasis of this study which considers PHC stakeholders in their environment utilising CBHIS to perform appropriate tasks.
	IR2 – The theory should be widely accepted within the IS domain and applied regularly since its proposal. These factors may be tested by considering the discussion and application of the theory in peer-reviewed studies over time.
	IR3 – The theory should have been applied across a wide range of systems.
	IR4 – The theory should contribute sufficient explanatory power which may be checked by the nature (can they be used to explain rather than simply measure?) and the range (are there enough types of concepts to effectively describe the phenomena?) of the concepts.
User requirements	UR1 – The compilation of the ILEs should be automated in the final tool by allowing the interactive tool users to provide the initialisation information electronically and subsequently presenting the resulting ILEs in an appropriate manner.
	UR2 – Each individual ILE should be restricted in the number of levels that is displayed by splitting the ILE at specific concepts and creating an additional ILE based on the concept.
User interface requirements	UIR1 – Match between system and the real world
	UIR2 – Consistency and standards
	UIR3 – Error prevention
	UIR4 – Recognition rather than recall
	UIR5 – Aesthetic and minimalist design
	UIR6 – Help and documentation

To develop the interactive tool, the requirements presented in Table 9.1 were pursued and met in the six design cycle iterations completed. These are summarised in Figure 9.1 and Figure 9.2, which depicts information to describe what is developed or evaluated in the corresponding components; how the relevance and rigour is established, and what methods are incorporated in each of the iterations.

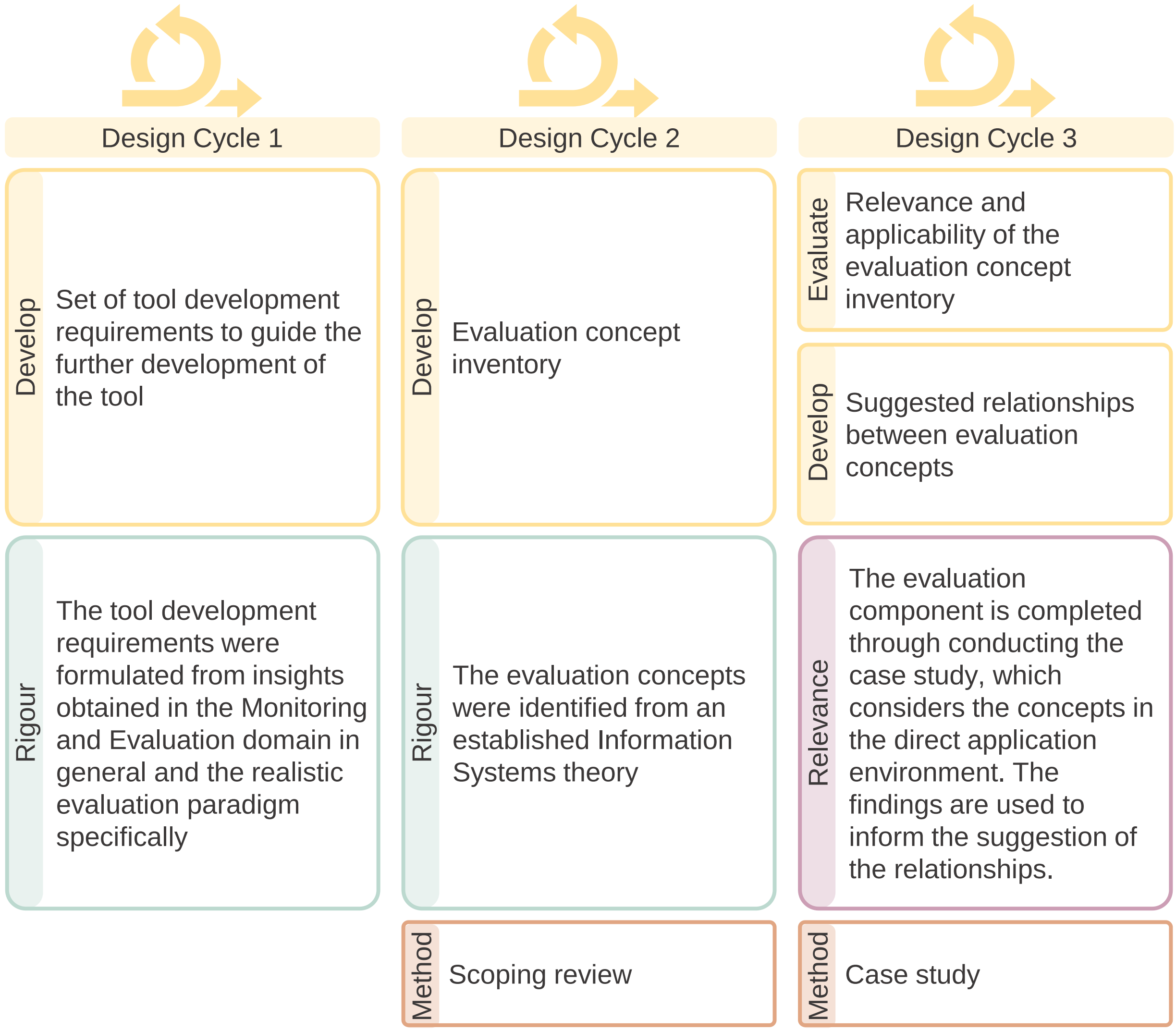


Figure 9.1 Design cycle iterations 1-3

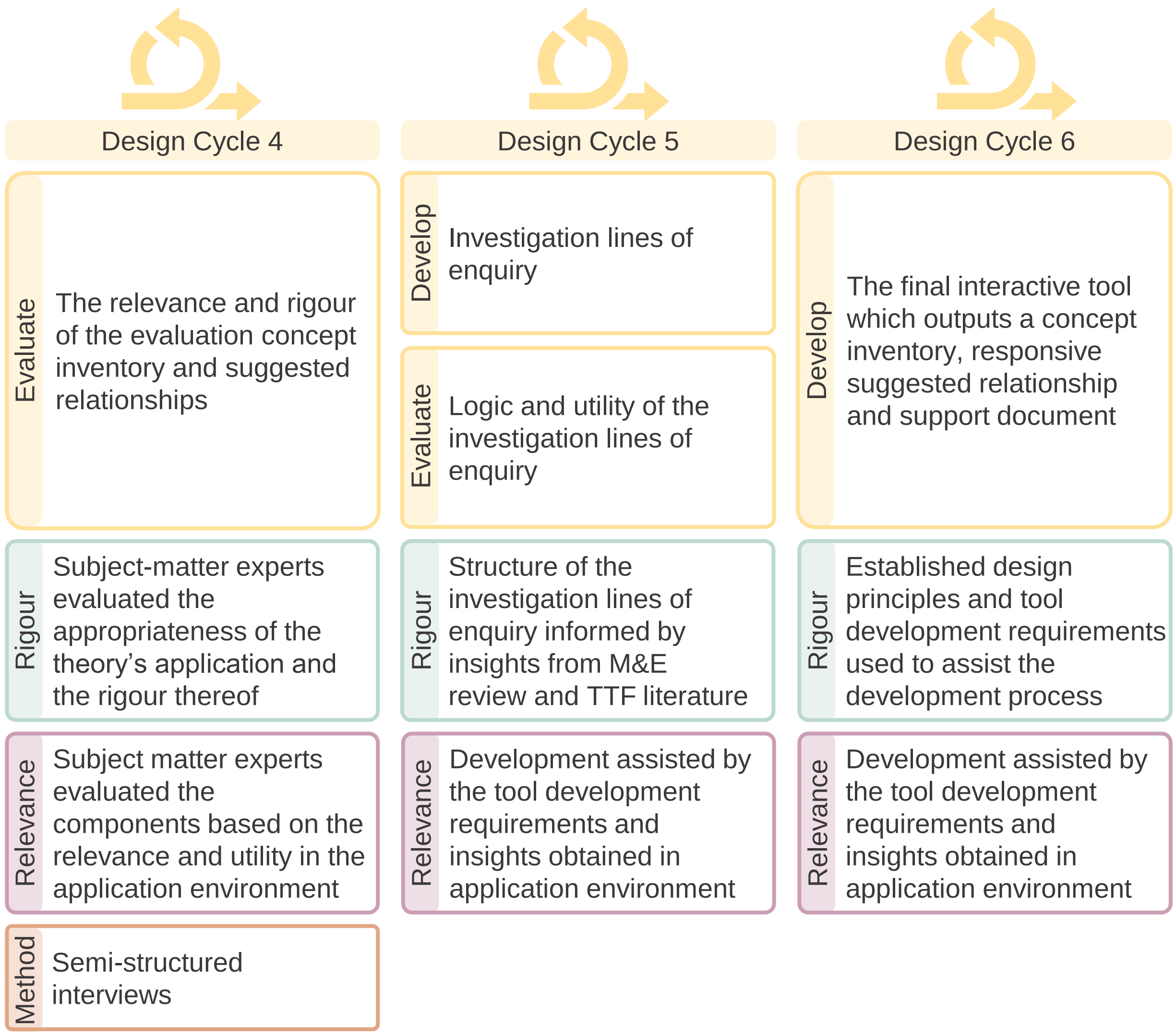


Figure 9.2 Design cycle iterations 4-6

The result of the six design cycles is the final interactive tool which provides users with three primary functional outputs: 1) a concept inventory, 2) a responsive concept map, and 3) an evaluation support document. A set of instructions is also provided to inform users of the functional outputs, their purpose and how they may be used. In the following section, the interactive tool is discussed to present its functionality and how it may be used.

9.4. Interactive tool presentation

The three functional outputs and a set of tool usage instructions are consolidated in the interactive tool. An overview of the interactive tool is provided in Figure 9.3, depicting the interactive tool navigation pane at the centre from which the various parts of the interactive tool may be accessed by the user. Furthermore, the three functional outputs are provided with a question word (such as *what?* and *how?)* that aid the discussion of the role each output plays to support the evaluation.

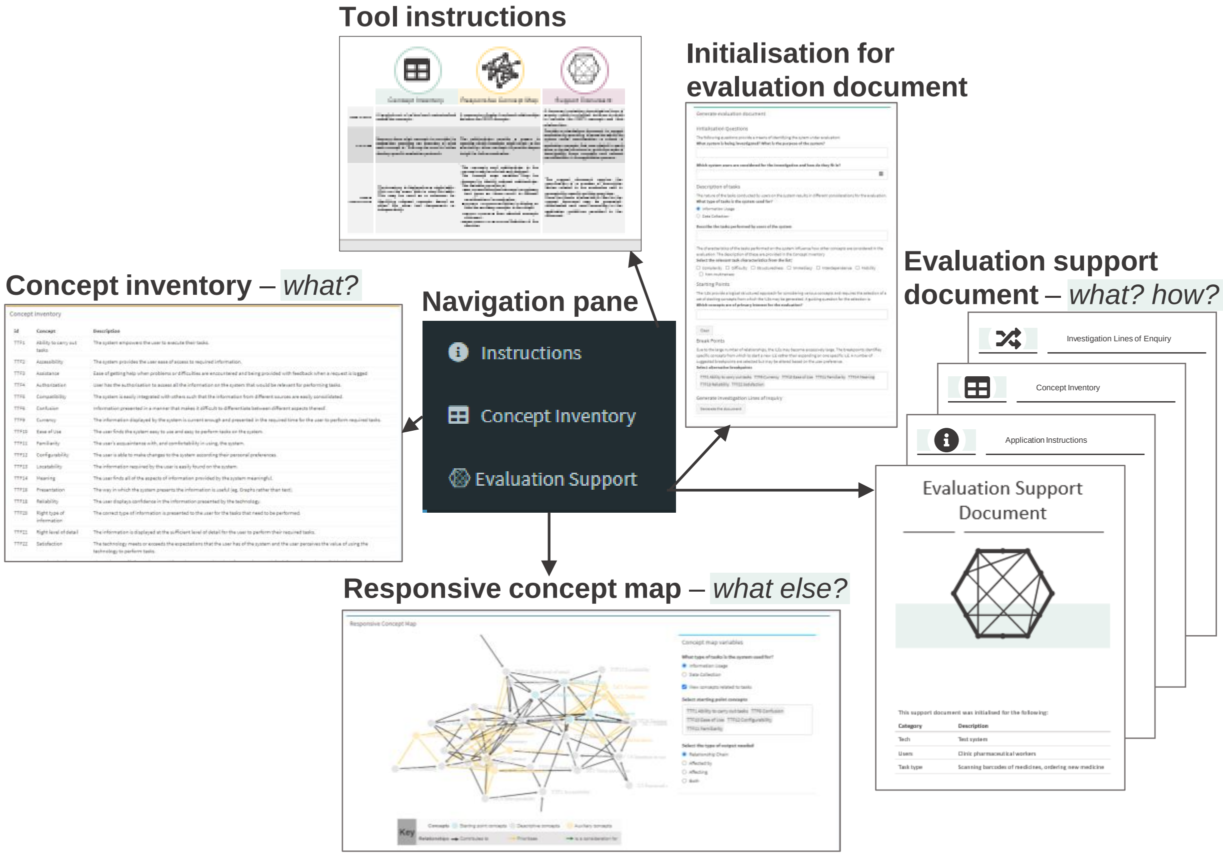
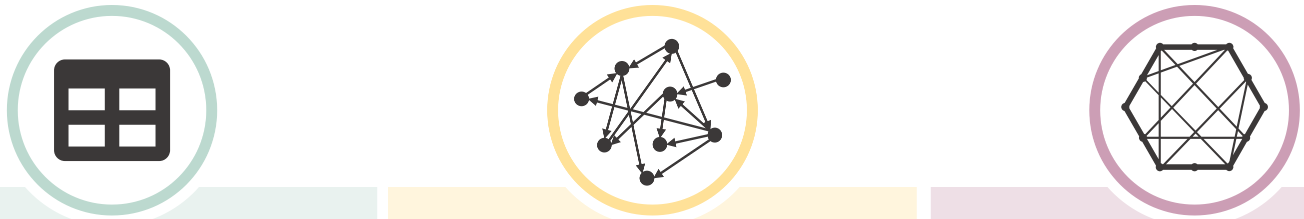


Figure 9.3 Overview of the interactive tool

In the following sections, the different parts of the interactive tool are discussed in detail along with how these may be used to support evaluation.

9.4.1. Tool usage instructions

Although the tool usage instructions are seen as a supportive output, it is a necessary component to ensure the ease of understanding and appropriately using the interactive tool. The instructions, depicted in Figure 9.4, are presented in a concise manner, such as to only provide the necessary information for user to understand *what* each output is, its *purpose* and basic *usage instructions*.



	Concept Inventory	Responsive Concept Map	Support Document
Description	A tangible set of refined and contextualised evaluation concepts.	A responsive display functional relationships between the RECI concepts.	A document containing investigation lines of enquiry, which is a logical structure in which to consider the RECI concepts and their relationships.
Purpose	Narrows down what concepts to consider for evaluation, providing an overview of what each concept is. This may be used to further develop specific evaluation protocols.	The relationships provide a means to consider which concepts might affect, or be affected by, other concepts to provide deeper insight for further evaluation.	Provides a standalone document to support evaluation by providing information about the system under consideration, a subset of evaluation concepts that are related to each other, a logical structure to guide the order of investigating these concepts and relevant considerations in the application process.
Usage Instructions	The inventory is displayed as a single table. Click on the menu item to view the table. This may be used as a reference for identifying relevant concepts based on either the other tool components or independently.	The concepts and relationships in the concepts may be clicked and dragged. The concept map variables may be changed to identify relevant relationships. The variables consists of: **Task type –** Selection between two primary task types as these result in different considerations for evaluation. **Auxiliary concepts –** Option to display or hide the auxiliary concepts in the output. **Starting points –** User selected concepts of interest. **Relationship direction –** Selection of the direction.	The support document requires the specification of a number of descriptive factors related to the evaluation and is prompted by specific guiding questions. Once the former information is filled in, the support document may be generated, downloaded and used according to the application guidelines provided in the document.

Figure 9.4 Evaluation support tool usage instructions

The display provides sufficient information for users to understand what the various outputs are and how to approach it. Each output was designed in such a way that it provides sufficient details to guide its usage. These outputs are discussed in the following sections.

9.4.2. Concept inventory

The concept inventory supports evaluation by providing a tangible set of refined and contextualised evaluation concepts that may be considered for, to inform, or to focus CBHIS evaluation efforts, thereby answering the question *what concepts should be considered?* The inventory is displayed in a simple table format that provides the identifiers of the concepts used throughout the study, the concept names and the descriptions as shown in Figure 9.5, which displays a portion of the output in the interactive tool.

Concept inventory

id	Concept	Description
TTF1	Ability to carry out tasks	The system empowers the user to execute their tasks.
TTF2	Accessibility	The system provides the user ease of access to required information.
TTF3	Assistance	Ease of getting help when problems or difficulties are encountered and being provided with feedback when a request is logged
TTF4	Authorization	User has the authorisation to access all the information on the system that would be relevant for performing tasks.
TTF5	Compatibility	The system is easily integrated with others such that the information from different sources are easily consolidated.
TTF6	Confusion	Information presented in a manner that makes it difficult to differentiate between different aspects thereof.
TTF9	Currency	The information displayed by the system is current enough and presented in the required time for the user to perform required tasks.

Figure 9.5 Portion of the concept inventory output in the interactive tool

The set of evaluation concepts in the inventory was found to be interrelated and these relationships between concepts provide further valuable insight for evaluation. These are discussed in the following sections.

9.4.3. Responsive concept map

The responsive concept map is a visual depiction of the relationships between the inventory concepts. The relationships provide a means to consider which concepts might affect, or be affected by, other concepts in order to guide a more comprehensive evaluation of multiple socio-technical aspects of a system which influence each other. The interrelated nature of the concepts supports evaluation by providing an understanding of how concepts may influence each other and therefore answer the question *what else needs to be considered?* The concept map may be used prior to or during an evaluation as well as during the exploration of ILEs (discussed in the following section) to identify additional concepts which may be of interest due to their relationships.

A screenshot of the responsive concept map output in the interactive tool (excluding the concept map key) is depicted in Figure 9.6.

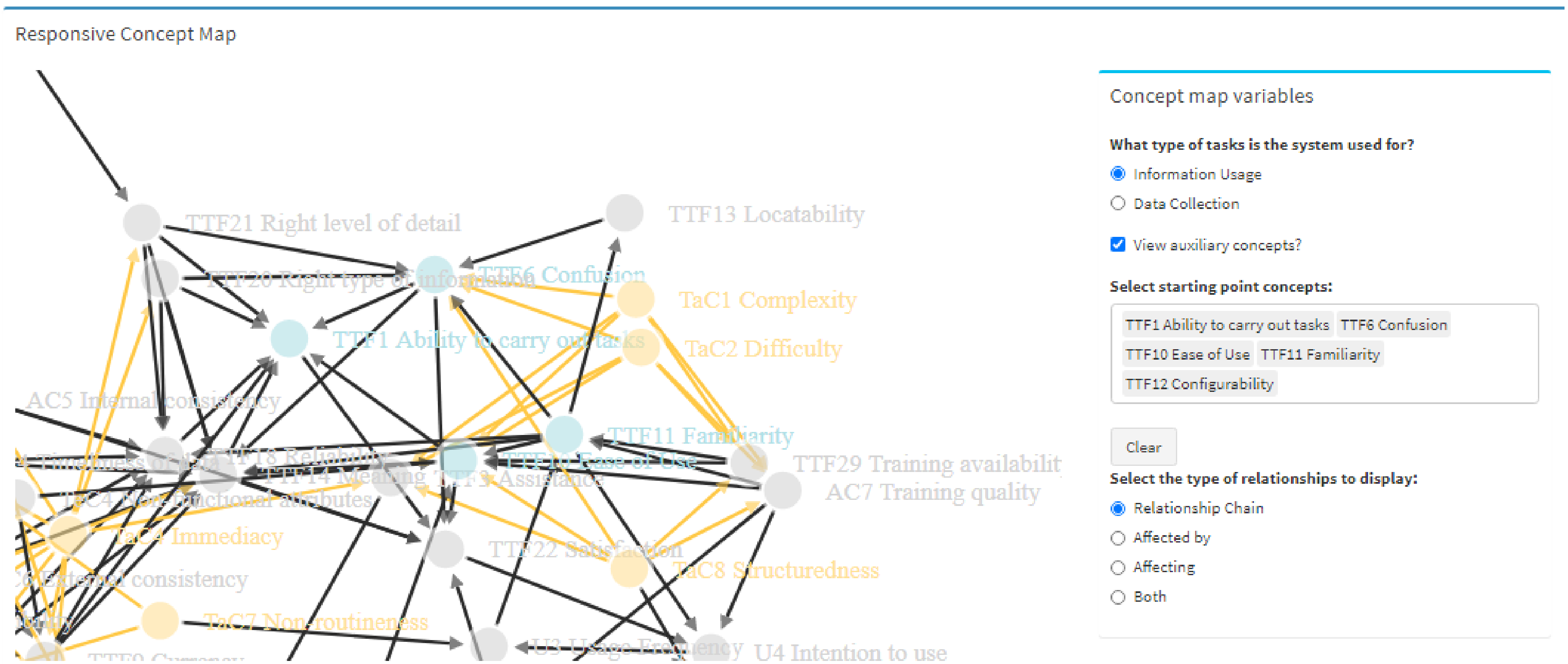


Figure 9.6 Illustration of the responsive concept map output

The concepts are depicted as coloured nodes based on the type of concept and are labelled according to concept ID and name. The relationships are depicted as coloured arrows between the concepts based on the type of relationship. A key, depicted in Figure 9.7, is provided along with the concept map that aids the interpretation of the display by providing a description of the various concept and relationship categories.

Concepts	Starting point concepts	The concept selected by the user for consideration.
	Descriptive concepts	Can be used to describe different facets of the system and may be applied for evaluation purposes.
	Auxiliary concepts	Contributes to the way in which the descriptive concepts are considered (see relevant relationship).
Relationships	Contributes to	The former concept is identified as potentially contributing to the latter concept. This relationship may reveal insight as to multiple concepts which influence the prominence of the initial concept considered. **Example**: Information being presented in an appropriate manner contributes to the user finding the information meaningful.
	Prioritises	The prominence of the former concept provides grounds for the latter concept to be considered in greater detail (thus prioritises). **Example**: If decisions are urgent then the information presented needs to be timely.
	Is a consideration for	The former concept provides an additional consideration for the latter concept. **Example**: If tasks are not routinely performed then the timeliness of the data collected will be affected and the way timeliness is considered should be different to routine tasks.

Figure 9.7 Concept map key displayed as part of the output

Due to the size and complexity of the concept maps associated with the two primary user-system tasks, the concept map output was developed to be responsive to user selected parameters. This allows users to easily identify pertinent concepts and relationships by modifying the inputs. In Table 9.2, the rationale for the different concept map parameters is discussed along with a description of the effect each parameter has on the concept map's display.

Table 9.2 Description of concept map parameters and the effect on the output

Concept map parameters	Values	Rationale	Effect on concept map display
Type of tasks system is used for	Information usage, data collection	The relationships between the concepts are different for the two types of tasks and the concept map.	Relevant set of relationships are displayed based on the selection.
View auxiliary concepts	Yes, No	The auxiliary concepts do not provide direct insight about evaluations and it may be in the interest of the user to hide these to only consider the concepts that do.	The concept map either displays the auxiliary concepts and their respective relationships or not.
Starting points	All descriptive concepts	Users may want to consider the relationships between specific concepts.	The concept map filters the concepts and relationships to only show those that are related, in the type of relationship selected, to the selected starting point concepts.
Relationship types	Relationship chain, affecting, affected by, both affecting and affected by	All of the relationships provide different insights which may support evaluation. Users may therefore want to consider any of these types of relationships from the selected starting point concepts.	

In APPENDIX F, various combinations of the concept map parameters are examined to demonstrate how the concept map display responds.

The relationships displayed in the responsive concept map is further used to formulate ILEs which is a structure that provides a suggested, sequential order of investigating all collectively related concepts. The ILEs are included into an evaluation support document which is compiled by the interactive tool based on various inputs by the interactive tool users. The support document and its suggested usage process is discussed in the following section.

9.4.4. Evaluation support document

The interactive tool generates a downloadable evaluation support document which is considered to be the most valuable output of the interactive tool and as it synthesises all of the former aspects into a single, standalone, printable document to support the evaluation of CBHIS. The process depicted in Figure 9.8 shows the tasks associated with the document and allows the questions *what concepts should be considered* and *how should the concepts be considered* to be answered.

The top component of the process depicts the tasks associated with the user of the interactive tool and document while the bottom component depicts the high-level tasks performed in the backend of the interactive tool. The user associated tasks are split into two parts, namely *initialisation* and *usage,* and the usage part is further broken down into an *exploration* phase, in which the ILEs are considered, and the *evaluation* phase in which the findings from the ILEs are used to support evaluation.

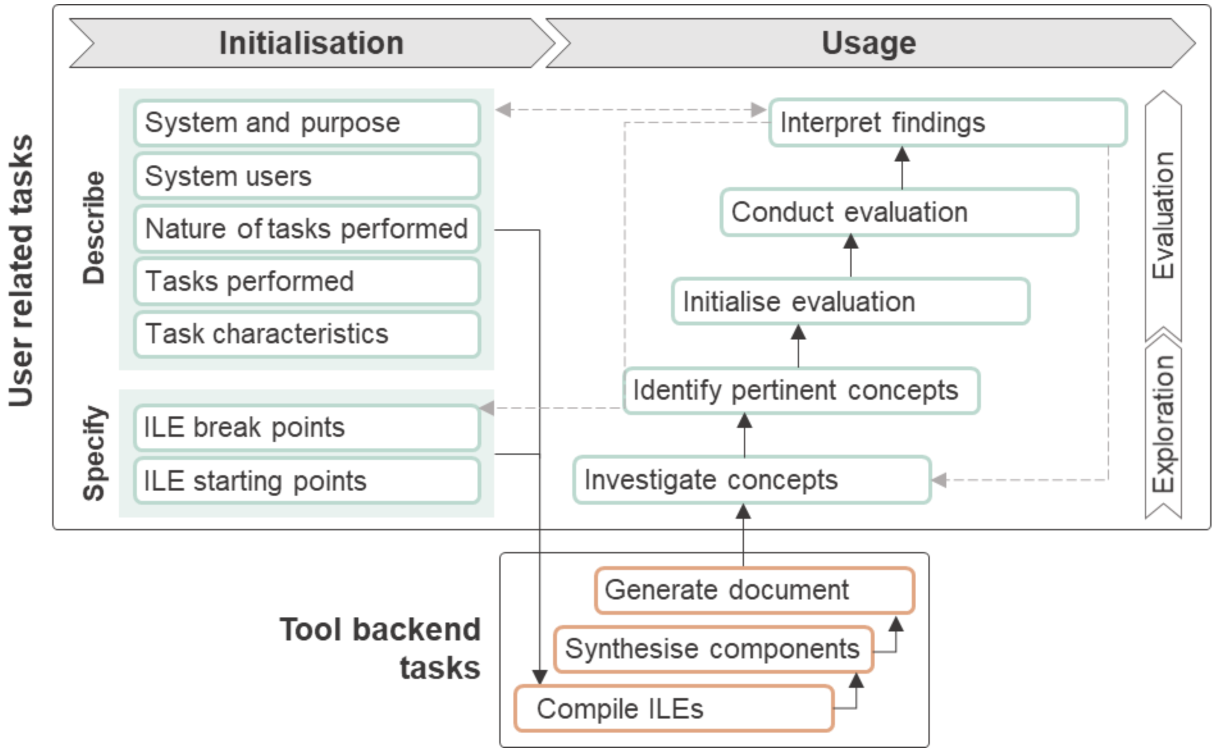


Figure 9.8 Process for using the evaluation support document

In the following sections, the various aspects of the support document are discussed in context of the process depicted in Figure 9.8. To aid the explanation and demonstrate the utility of the interactive tool within its usage context, a simple hypothetical example scenario is incorporated. This scenario was formulated as follows:

An alarming number of stockouts were identified at a specific clinic. The clinic pharmacist is responsible for ordering stock and uses information from a stock management system to do so. Upon investigation, it was found that the correct amount of stock ordered was consistently delivered on time and therefore management suspect that the problem lies with the stock management system. An evaluation of the system was commissioned such as to identify potential problems with the system or the usage thereof.

9.4.4.1 Initialisation of evaluation support document

The initialisation part of the process requires the user to specify all the necessary information for the evaluation support document to be generated. The various information depicted in Figure 9.8 as *describe* specifies a number of descriptive factors that contribute in multiple ways to support the evaluation. This is described in Table 9.3 along with the specific questions to prompt users.

Table 9.3 Descriptive information specified by users

Descriptive factors	Questions
Description of system	What system is being investigated? What is the purpose of the system?
Description of the users	Which system users are considered for the investigation and how do they fit in?
Description of tasks	What type of tasks performed on the system is considered? Describe the tasks performed by users of the system.
Description of task characteristics	Which of the task characteristics that form part of the evaluation concept inventory are applicable/prominent in the tasks?

The interactive tool at large contributes explanatory power for evaluation and supports answering the evaluation question *what works for whom in what circumstances*. The descriptive information specified by the users provide a means of explaining the latter components: *for whom* and *in what circumstances.* This is further discussed in Section 9.4.4.4.

The initialisation part of the process also requires users to specify a set of *starting points* and *break points*. The ILEs provide a logical structured approach for considering various concepts and requires the selection of a set of starting concepts from which the ILEs may be generated. The user is prompted with a guiding question to select the pertinent concepts: *which concepts are of primary interest for the evaluation?*

All of this former information is prompted in a user form; a screenshot of the form is shown in Figure 9.9. The screenshot also contains the demonstrative information from the example scenario described in Section 9.4.4. For the evaluation support document, the stock management system, which provides real-time transparency of stock levels for all medication on hand, is considered.

The system is used by a clinic pharmacist who is responsible for making decisions about the quantity of stock ordered. The clinic pharmacist views the stock levels of medication and makes ordering decisions based thereon. This task needs to be suddenly performed without delay and therefore the *immediacy* task characteristic is selected.

Not only does the task need to be performed in a timely manner, the information displayed to the pharmacist needs to reflect current, real-time stock levels. Furthermore, the information displayed to the pharmacist needs to be reliable. Two starting point concepts were therefore selected, namely: *TTF9 Currency* and *TTF18 Reliability.* To ensure that the ILEs do not become excessively long, the system suggested breakpoints were accepted.

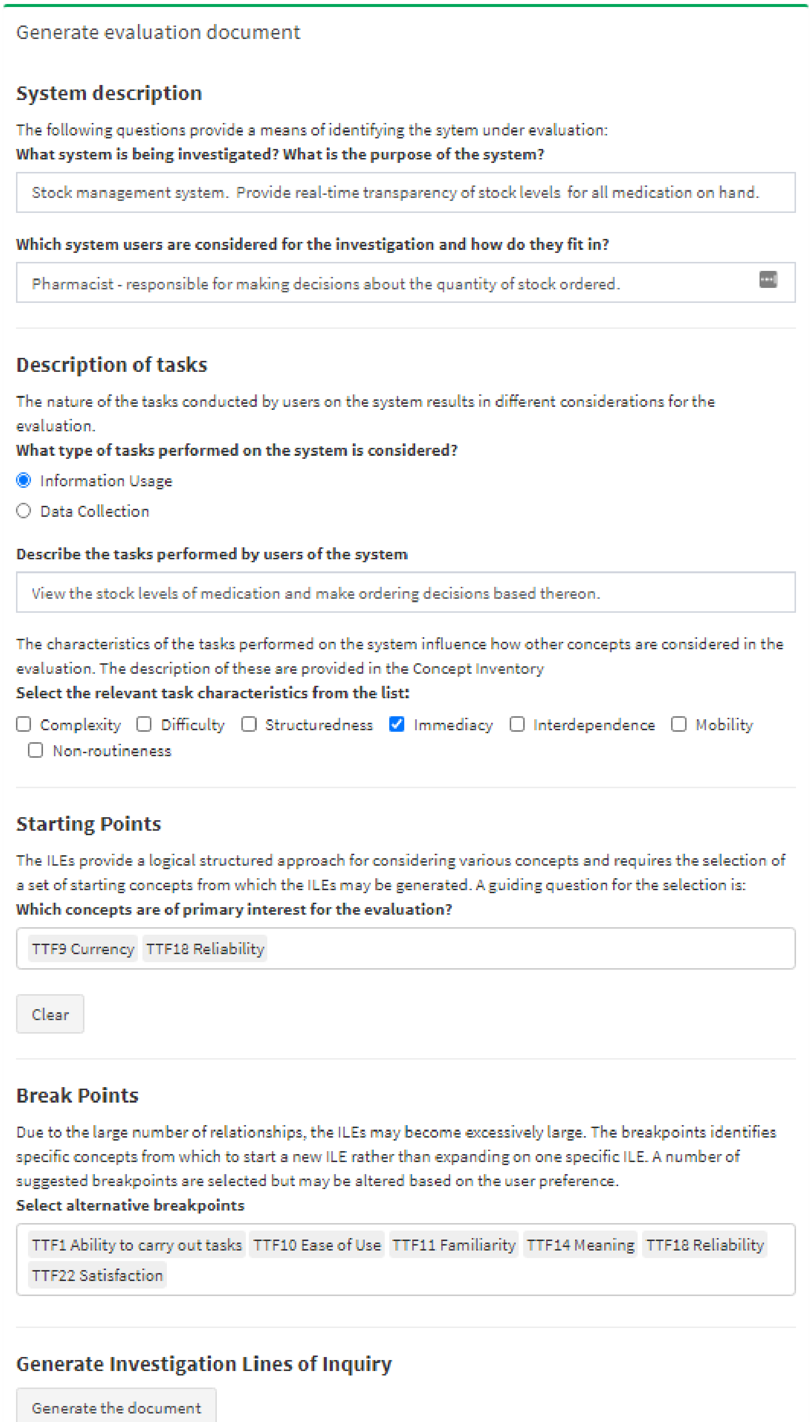


Figure 9.9 Screenshot of the initialisation section for the evaluation support document

The interactive tool processes all of the former information in the background, executing various functions which manipulate the user inputs and predefined system variables, to compile the ILEs, synthesise the information, and generate the downloadable support document. The content of the document is discussed in the following section.

9.4.4.2 Evaluation support document content

The evaluation support document comprises a number of different sections, namely, a cover page; application instructions; the concept inventory; and the ILEs. The interactive tool compiles the support document such that each section appears on a new page. The evaluation support document compiled from the initialisation tasks described in the previous section can be found in APPENDIX G.

The cover page consists of a generic image and a table describing the system, users and tasks specified in the initialisation of document. This allows documents to be easily identified and referred to in the future.

The application instructions section of the document provides guidance on how the document may be used. These are kept concise and incorporates multiple graphics to demonstrate the process. The instructions include two sub-sections. The first subsection is depicted in Figure 9.10, which provides an overview of the document content followed by a set of guidelines to explore the ILEs.

The ILEs are structures which provide a suggested, sequential order of investigation that is formulated by identifying an initial concept to be investigated and sequentially structuring all collective related evaluation concepts. The ILEs incorporate the interrelated nature of the concepts while providing a generic approach to simplify the concept map and logically guiding the investigation process. Investigation refers to the process of considering each individual concept part of an ILE. Exploration collectively refers to 1) the investigation of multiple concepts in the various ILEs, since the support document may contain multiple ILEs, and 2) the process of determining whether a concept is pertinent for further investigation. The instructions depicted in Figure 9.10 therefore provide guidelines on to both approach the investigation and identification of pertinent concepts.

The guidelines refer to various elements that are used in the ILEs. The second instruction sub-section, depicted in Figure 9.11, provides a detailed explanation of all the elements that make up the ILEs and how they may be interpreted.

Application Instructions

Document contents

Concept Inventory

The set of evaluation concepts that is used as a reference for the exploration of the ILEs and investigation of concepts.

Investigation lines of enquiry

A structure which provides a suggested, sequential order of investigation that is formulated by identifying an initial concept to be investigated and sequentially structuring all collective related evaluation concepts. The purpose of the ILEs is to identify a set of relevant concepts which may be used to inform more comprehensive evaluation

An infographic describing how these may be best understood and used is presented on the following page

Investigation lines of enquiry application guidelines

Exploration guideline 1: Investigate concept based on the concept description and determine the relevance of the concept based on system or evaluation context	The set of concepts included in the inventory all provide important considerations for evaluation. The presence of a concept in an ILE suggests its importance based on the selection of a starting concept. The concept description should aid to understanding what a concept refers to.
Exploration guideline 2: Where applicable, review the additional considerations provided by the auxiliary concepts	The presence of the auxiliary concepts identified in the initialisation phase prioritises certain descriptive concepts or provides a way to interpret these concepts. Specific attention should be given to concepts which are related to the applicable auxiliary concepts.
Exploration guideline 3: Determine concept pertinence for further evaluation based on system or evaluation context	The pertinence of concepts should be determined by the investigator based on the specific system, its context, and the evaluation context. If the concept description is found to be insufficient to identify the pertinence thereof, the investigator should use the description to guide the identification of more detailed measures that may be applied to determine the relevance.
Exploration guideline 4: If a concept is not found to be pertinent, then further related concepts do not need to be investigated	The ILEs provide a structured approach to identify consider concepts that are related to each other, and consequently may influence the state of the system. Therefore, if a concept is found to be irrelevant then the concepts that influence the concept under consideration do not need further investigation.
Exploration guideline 5: Consider related descriptive concepts and the type of relationship	The relationships between concepts may provide a greater understanding of factors that influence the functioning of the system. The influence of the related concepts should be considered based on the type of relationship and investigating the related concepts.
Exploration guideline 6: Use the concept relationships and ILE structure to guide the order of investigation.	The ILEs are structured sequentially based on the relationships between concepts. These may be used as a reference for ordering the investigation.

Figure 9.10 First sections of instruction in the evaluation support document

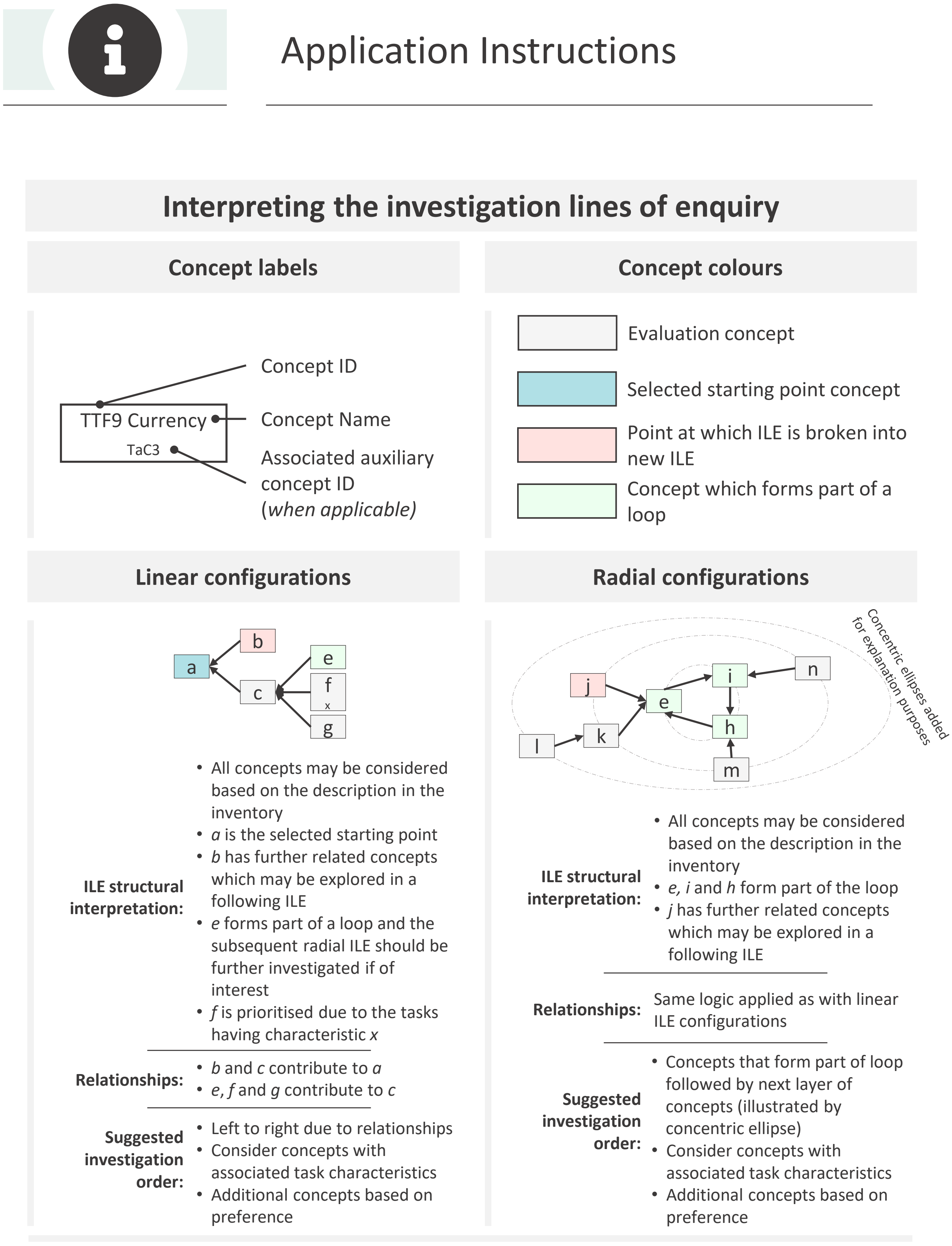


Figure 9.11 Guidance for interpreting the investigation lines of enquiry

The following support document section contains the complete concept inventory which is also presented in the interactive tool (Section 9.4.2). This is presented as a single table containing the ID, concept and concept description which serves as a reference for the ILEs.

The final ILE section of the support document provides a summary of the information specified by the user during the initialisation of the document, which provides background and context for interpreting the ILEs, and thereafter the relevant set of ILEs are presented. In the following section, the example scenario is used to demonstrate how the ILEs presented of the document may be applied to support evaluation.

9.4.4.3 Exploration of the investigation lines of enquiry presented in the support document

The set of ILEs generated based on the initialisation information specified in Section 9.4.4.1 is presented in the support document provided in APPENDIX G. A single ILE from the document, depicted in Figure 9.12, is used to demonstrate how the ILEs may be used to support evaluation following the process described in the instructions of the support document (Section 9.4.4.2).

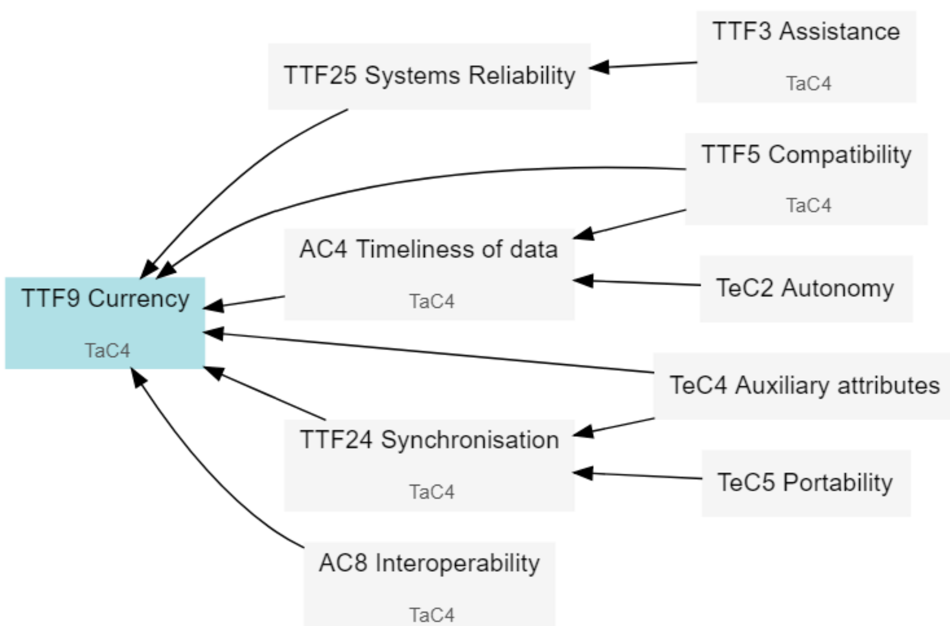


Figure 9.12 ILE with TTF9 Currency as starting point

As described in the instructions, the exploration of the ILEs consists of investigating concepts part of each ILE and determining its relevance. The execution of these steps based on the ILE depicted in Figure 9.12 and an elaboration of the hypothetical example scenario are described in Table 9.4, which further references the corresponding guideline which informed each step.

Table 9.4 Exploration of the example ILE

Step	Explanation	Corresponding guideline
Step 1: Investigate starting concept	Currency was selected as the starting point and is prioritised due to the presence of Tac4. Upon reviewing the description, the concept is deemed relevant for further evaluation as it has been noted that by system users that the information is often not up to date.	ILE interpretation, exploration guideline 1-3

Step 2: Determine order of investigation	The related concepts should be investigated next. The order of investigation is based on 1) the prioritised concepts due to TaC4 and 2) the structure of the ILEs. Since it is not necessary to consider concepts related to irrelevant concepts, the investigation order includes a number of if statements and is set out as:
	
	1. Investigate AC8
	2. Investigate AC4
	    a. Investigate TTF5
	    b. If AC4 is pertinent, investigate TeC2
	3. Investigate TTF24
	    a. Investigate TeC4
	    b. If TTF24 is pertinent, investigate TeC5
		Exploration guideline 4-6

Step	Explanation	Corresponding guideline
Step 3: Investigate the concepts and determine pertinence	For each of the concepts under investigation, the concept was considered based on: 1. What is known about the system? 2. An analysis of system and its usage 3. Consulting relevant stakeholders The investigation is used to determine the pertinence of the concept for further evaluation. The pertinence of the concepts, arranged in the investigation order, was found to be: 1. AC8: irrelevant – system built according to national interoperability standards 2. AC4: pertinent – the information used to order stock is compiled from multiple data sources submitted by other clinic workers. The data was found to be submitted late on a regular basis. a. TTF5: irrelevant – the system is compatible b. TeC2: irrelevant – in the current environment, automating the process is not possible. 3. TTF24: irrelevant – the exchange of information takes place frequent enough a. TeC4: irrelevant – The devices are capable of completing all of the tasks b. TeC5: irrelevant by default as TTF24 is irrelevant	Exploration guidelines 2-3

The example process followed in Table 9.4 may be followed for each of the ILEs presented in the support document. The pertinent concepts identified in the exploration of the ILEs may then be used along with the descriptive information specified during the initialisation phase to inform the evaluation, as discussed in the following section.

9.4.4.4 Support of the evaluation based on the insight from the document

The definition and execution of the evaluation is to be determined by the evaluator. The interactive tool and support document do not prescribe any method or content for evaluation, but they provide generic information which may be used to support the evaluation. Four elements that are typically included in an evaluation process are depicted in Figure 9.13 to demonstrate how the ILEs may provide support.

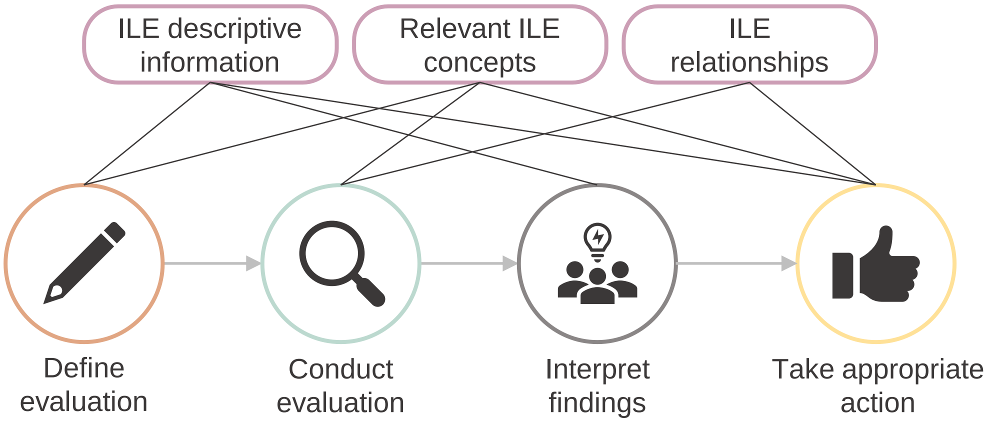


Figure 9.13 Contribution of ILEs to typical evaluation process elements

In the definition of evaluation objectives and methodology, the descriptive information from the initialisation phase provides important information to understand the context of the evaluation. Furthermore, the exploration phase of the ILEs provide insight into a set of evaluation concepts that were identified as being pertinent for further evaluation which may be used to appropriately focus the evaluation.

During evaluations, ILEs may be used to provide a more comprehensive understanding of how different socio-technical aspects of the systems are related. This may allow evaluators to take appropriate action in adding additional aspects to the evaluation or refining existing measures for the aspects under evaluation to best reflect the real-world scenario.

The interpretation of the findings may also be considered alongside the descriptive information as it provides contextual information. This is important as the specific outcomes of the evaluation is seen to be context-bound and should therefore be interpreted based on the context. The information allows the findings to be phrased in terms of *what works, for whom and, under what conditions* – in line with the realist evaluation paradigm.

Finally, evaluations are typically conducted to take appropriate action based on the findings in order to improve various aspects of the system. Based on the relationships between concepts, the ILEs provide insight as to what concepts may additionally be focused on to improve potentially problematic areas, and what other concepts may be affected when action is taken. The responsive concept map in the interactive tool may also be used to identify these concepts or other concepts of interest. The findings of the evaluation may also highlight additional areas of interest for investigation and guide the investigator to consider the ILEs in different areas of system usage, different users, or additional concepts to consider, thereby initiating another ILE application process.

9.5. Concluding remarks: Chapter 9

In this chapter, the main research question[9] is answered through presenting the interactive tool. The motivation and purpose of the interactive tool is discussed. This is followed by an overview of the iterative process followed to develop the interactive tool, which is discussed in depth throughout the document.

[9] MRQ: How can the evaluation of clinic-based health information systems be supported by an interactive tool?

Finally, each aspect of the interactive tool is introduced and discussed, using a hypothetical example scenario to demonstrate the interactive tool functionality.

The various functional outputs of the interactive tool are summarised in Table 9.5 along with an explanation of how these may contribute to support the evaluation of CBHIS.

Table 9.5 Contributions of the interactive tool functional outputs to support the evaluation of CBHIS

Functional output	Contribution to support the evaluation of CBHIS
Concept inventory	The inventory provides a tangible set of refined and contextualised evaluation concepts that may be considered, to inform, or to focus CBHIS evaluation efforts, thereby answering the question *what socio-technical aspects should be considered?*
Responsive concept map	The relationships depicted between concepts in the concept map which provide a means to consider the interrelated nature of the concepts help guide towards a more comprehensive evaluation of multiple socio-technical aspects of a system which influence each other. The interrelated nature of the concepts supports evaluation by providing an understanding of how concepts may influence each other and therefore answer the question *what else needs to be considered?*
Evaluation support document	The evaluation support document synthesises both the former concepts and contextual information specific to the system under consideration. This ultimately supports evaluation by: 1. Systematically guiding the identification of pertinent concepts that may inform the appropriate and focussed formulation of the evaluation. 2. Contributing to a more comprehensive understanding of how different socio-technical aspects of the systems are related and thereby allowing evaluators to take appropriate action by adding additional aspects to the evaluation or refining existing measures for the aspects under evaluation to best reflect the real-world scenario. 3. Providing important contextual information for an accurate interpretation of the findings. 4. Providing a comprehensive understanding of what socio-technical aspects may be focussed on to improve potentially problematic areas.

Furthermore, the interactive tool meets all the tool development requirements which aimed to ensure that the interactive tool effectively meets the aims of this study. The fulfilment of these requirements are presented in Table 9.6 (pages 133-134), indicating aspects of the interactive tool or development process along with the corresponding section in the document where this is described.

The discussion of various aspects of the interactive tool, demonstration of its usage process, and explicit specification of its potential contributions to support the evaluation of CBHIS answers this study's main research question and provides important considerations for applying the interactive tool in practice. Having answered the main research question in this chapter, the study is concluded in the following chapter.

Table 9.6 Fulfilment of the interactive tool development requirements

Tool development requirements		Interactive tool					**Development process**	Section reported
		General tool interface	Concept inventory	Responsive concept map	Evaluation support document	ILEs		
Functional requirements	FR1 – The interactive tool should use and adapt terminology in a manner consistent with M&E language, specifically that of the realistic evaluation, and should empower users to communicate findings in a manner consistent with “what works, for who and under what conditions”.		✓		✓			**Chapter 9** Section 9.4.2 Section 9.4.4
	FR2 – The interactive tool requires a robust structure which is consistent with the causal logic and presented in a simple manner with only the necessary evaluation components.					✓		**Chapter 8**
	FR3 – The interactive tool should provide sufficient implementation guidance to ensure its utility while not over-constraining the interactive tool.	✓	✓	✓	✓	✓		**Chapter 9** Section 9.4
	FR4 – The interactive tool should present concepts and guide the evaluation process to ensure that the findings are able to be communicated in an explanatory manner.				✓	✓		**Chapter 9** Section 9.4.4
Identification requirements	IR1 – The theory should align with the overall emphasis of this study which considers PHC stakeholders in their environment utilising CBHIS to perform appropriate tasks.						✓	**Chapter 4** Section 4.8
	IR2 – The theory should be widely accepted within the IS domain and applied regularly since its proposal. These factors may be tested by considering the discussion and application of the theory in peer-reviewed studies over time.						✓	
	IR3 – The theory should have been applied across a wide range of systems.						✓	

Tool development requirements		Interactive tool					**Development process**	Section reported
		General tool interface	Concept inventory	Responsive concept map	Evaluation support document	ILEs		
	IR4 – The theory should contribute sufficient explanatory power which may be checked by the nature (can they be used to explain rather than simply measure?) and the range (are there enough types of concepts to effectively describe the phenomena?) of the concepts.						✓	
User requirements	UR1 – The compilation of the ILEs should be in automated in the final tool by allowing the interactive tool users to provide the initialisation information electronically and subsequently presenting the resulting ILEs in an appropriate manner.				✓	✓		**Chapter 8** Section 8.3
	UR2 – Each individual ILE should be restricted in the number of levels that is displayed by splitting the ILE at specific concepts and creating an additional ILE based on the concept.				✓	✓		**Chapter 9** Section 9.4.4
User interface requirements	UIR1 – Match between system and the real world.	✓						**Chapter 9** Section 9.4
	UIR2 – Consistency and standards	✓						
	UIR3 – Error prevention	✓						
	UIR4 – Recognition rather than recall	✓						
	UIR5 – Aesthetic and minimalist design	✓						
	UIR6 – Help and documentation	✓						

Chapter 10. Conclusion and future work

10.1. Introduction

In this final chapter, an overview of the research process is provided, the research findings are presented, and the various contributions made in the completion of this study are discussed. The limitations of the study are discussed as well as suggestions for further research opportunities. The chapter concludes with the personal reflections of the researcher.

10.2. Overview of the research process

The aim of this study was to support the evaluation of clinic-based health information systems through the development of an interactive tool. The execution of this study was based on the DSR framework and process model and consisted of four major phases, each comprising of individual steps. The execution of six design cycle iterations, which draw from the application environment and knowledge, are also pursued in these phases[10]. A summary of the research process is depicted in Figure 10.1.

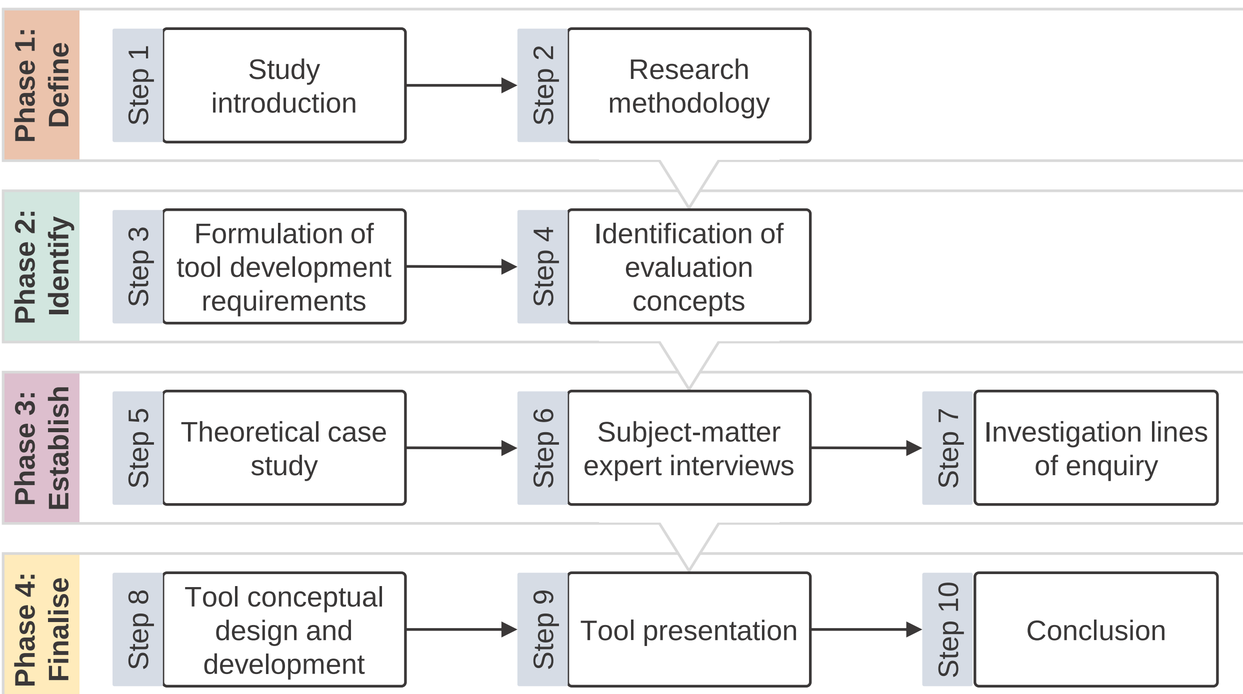


Figure 10.1 Overview of the research process followed in this study

An overview of the work completed in each phase is discussed in the following sections.

10.2.1. Phase 1: Define the study

The first phase aimed to appropriately define the various aspects of this study. In **step 1** the study was introduced; the background of the study, problem statement, research objectives and questions were presented. In this chapter, the importance of HIS, particularly CBHIS, was emphasised; the important role of

[10] The presentation of the tool in Chapter 9, details the execution of the six design cycle iterations

evaluating these systems to aid their improvement was discussed; and the need to support these evaluations was established. This study was appropriately aligned to these findings; the overall study aim, research questions and research objectives were defined accordingly.

In **step 2**, the four-phase, ten-step research design that would effectively and innovatively meet the aims and objectives set out in this study, and be able to both guide the research process and the development of the interactive tool was formulated. The research design was *based on* the DSR framework and process model, *influenced by* the design paradigm, and *informed by* three primary, overlapping domains and *supplemented by* various research methods.

The outcome of these two steps provide the foundation for pursuing the aim of the study through completion of the subsequent phases discussed in the following sections.

10.2.2. Phase 2: Identify the building blocks for the interactive tool development

The second phase aimed to answer the two sub-research questions and thereby identify and synthesise established, context-appropriate information from which the interactive tool may be developed. This was achieved in two steps.

SRQ 1 was answered in **step 3** by formulating a set of tool development requirements by identifying and leveraging insights from a review of the M&E domain. The review considered important evaluation characteristics and functions that were leveraged to formulate functional requirements for the interactive tool. Furthermore, the realistic evaluation paradigm was discussed, and the insights gained were leveraged to formulate identification requirements which was used to support the identification of a tangible set of evaluation concepts in the following step.

In **step 4**, SRQ 2 is answered through identifying and cataloguing evaluation concepts which emerge from the application of the TTF theory in literature into an evaluation concept inventory. An overview of the TTF theory was provided and a scoping review was conducted. Based on the findings from the scoping review, the TTF theory was confirmed as appropriate based on the identification requirements formulated in step 3 and the evaluation concepts were catalogued and presented as the evaluation concept inventory.

The tool development requirements and the evaluation concept inventory provided a sufficient basis for further development of the interactive tool to establish the various tool components in phase 3. This is discussed in the following section.

10.2.3. Phase 3: Establish the interactive tool components

The third phase aimed to establish the various tool components towards answering the main research question and achieving the aim of this study. This was achieved in three steps, which incorporated research methods to support the execution thereof.

In **step 5**, the evaluation concept inventory was adapted to contribute to the relevance of the evaluation concepts to support the evaluation of CBHIS. Relationships between the evaluation concepts were also suggested towards establishing the second tool component. This was achieved by conducting a theoretical case study which allowed the evaluation concepts to be investigated within its real-life application environment. In the case study, documents associated with the evaluation of the Stock Visibility System, a CBHIS that supports national stock management, were analysed to identify evaluation concepts related to this study. The findings of the analysis was leveraged to: 1) confirm the relevance and applicability of evaluation concepts, 2) refine and contextualise the evaluation concepts, 3) supplement the evaluation concept inventory with additional, relevant evaluation concepts, and 4) suggest relationships between the evaluation concepts as informed by the co-occurrence of the evaluation concepts in the case study.

The evaluation concept inventory and concept map form the first two components of the interactive tool. In **step 6**, these components were evaluated by conducting multiple semi-structured interviews with SMEs. The SMEs consisted of two experts of the TTF theory, one individual with expertise in the M&E of CBHIS, and one individual involved in the development of CBHIS. The interviews were conducted, and the findings leveraged to, firstly, validate the appropriateness of how the TTF theory is applied in this study; secondly, to confirm the relevance and rigour of the components, and thirdly, adapt the components to further ensure the relevance and rigour of the interactive tool. Finally, focussed insights were obtained for further development of the interactive tool.

The SMEs identified the need for a robust structure that present the relationships between concepts in a simple manner in line with causal logic. Sufficient guidance for the application of these structures is also required. These findings were found to correspond with two of the tool development requirements identified in the previous phase.

The formulation of the structure was completed in **step 7** by the formulation of Investigation Lines of Enquiry (ILEs). The ILEs were formulated by identifying and leveraging structural qualities from the visual representation of relationships between evaluation concepts in the concept maps. Furthermore, a process was specified to guide the application of the ILEs and aid its utility in achieving the study objectives. The ILEs provide a robust logical structure that incorporates the interrelated nature of the concepts and provides practical guidelines for applying these. The ILEs were reviewed by the four SMEs who confirmed its logic and utility.

The evaluation concept inventory, concept map and the ILEs were found to provide a sufficient basis for the consolidation into a single interactive tool to support the evaluation of CBHIS which was pursued in the following phase

10.2.4. Phase 4: Finalise the interactive tool and report the findings

The fourth and final phase aimed to finalise the interactive tool to support the evaluation of CBHIS and to report on the overall findings of this study. This was achieved in three steps.

In **step 8**, the three tool components established in the previous phase were consolidated into the final interactive tool. The various components were reviewed to conceptually design the interactive tool. A final set of user interface design requirements were added to the tool development requirements which was subsequently used to guide the final development of the interactive tool. A structured, iterative approach influenced by the DSR approach was followed in the consolidation of all the interactive tool components and coding of the interactive tool, which was done using R and incorporated several relevant plugins. The outcome of this first step was the final interactive tool.

The main research question of this study was answered in **step 9** by presenting the final interactive tool to support the evaluation of CBHIS. An overview of the motivation for and purpose of the interactive tool was provided followed by a discussion of the iterative process followed in this study to develop the interactive tool. Thereafter, the various aspects of the interactive tool were discussed to demonstrate its functionality and describe how it supports the evaluation of CBHIS.

In **step 10**, the fourth phase and the study as a whole are concluded with the step pursued in this chapter. In the following section, the various research questions which guided this study is reflected on.

10.3. Reflection on the research questions

The aim of this study was to develop an interactive tool to support the evaluation of CBHIS. Three research questions were formulated to guide this study based on the overall aim. Furthermore, various research objectives were formulated to effectively meet the study aim and answer the research questions.

In the following sections, the research questions are reflected on and the fulfilment of their corresponding objectives are presented.

SRQ 1: How can insights gained from the Monitoring and Evaluation research domain be leveraged to assist the development of an interactive tool for supporting the evaluation of CBHIS?

The evaluation of CBHIS falls within the larger domain of Monitoring and Evaluation. This research question was answered by the formulation of the tool development requirements by identifying and leveraging specific insights from this research domain. The requirements aim to ensure that interactive tool aligns with the larger domain to effectively meet the study aim and to this end assists the development of the interactive tool.

To effectively answer this research question, Research Objective 1 was pursued and fulfilled in Chapter 3, particularly by *conducting* a detailed literature study of the Monitoring and Evaluation research domain. A number of sub-objectives were formulated and pursued in this respect. The fulfilment of these sub-objectives in the study is linked to specific sections in this document, as presented in Table 10.1.

Table 10.1 Research objectives addressed in support of answering the first sub-research question

Research objectives	Section where reported
Objective 1.a To *review* the role and characteristics of the complementary but separate functions of monitoring and evaluation.	Section 3.2
Objective 1.b To *select* and *discuss* an appropriate paradigm which aligns with the aim of this study, and capable of guiding the tool development process.	Section 3.3
Objective 1.c To *formulate* a set of tool development requirements based on the insights obtained in the pursuit of Objectives 1.a-c which guides the interactive tool development process and ensures that the interactive tool effectively achieves its aim.	Section 3.4
Objective 1.d To *suggest* an appropriate Information Systems theory that aligns with the requirements formulated in pursuit of Objective 1.d – from which focussed insights may be drawn.	Section 3.4

As stated in Objective 1.c, the insights obtained in the fulfilment of Objectives 1.a-c were synthesised to formulate a set of tool development requirements. These insights were categorised into two sets of requirements: firstly, a set of functional requirements which aimed to ensure that the final tool effectively supports evaluation by aligning with M&E principles and approaches; secondly, a set of identification requirements which aimed to aim to support the identification of a tangible set of evaluation concepts from the IS domain by guiding the selection of an appropriate IS theory. The identification of such concepts was pursued to answer SRQ 2 and is discussed in the following section.

SRQ 2: *How can the application of an Information Systems theory inform a tangible set of evaluation concepts to aid the development of the interactive tool for supporting the evaluation of CBHIS?*

The development of the interactive tool required a set of evaluation concepts grounded in the IS domain that may be appropriately leveraged to support the evaluation of CBHIS. This research question was answered through identifying and cataloguing evaluation concepts which emerge from the application of the TTF theory into an evaluation concept inventory.

To effectively answer this research question, Research Objective 2 was pursued and fulfilled in Chapter 4, particularly by *conducting* a systematised literature review (the scoping review) on the TTF theory suggested in pursuit of Objective 1.d. The TTF theory proposed by Goodhue and Thompson (1995) is a prominent IS theory that has been applied to numerous technologies across a wide range of environments and was selected as an appropriate theory from which to identify the evaluation concepts.

A number of sub-objectives were formulated and pursued to support Research Objective 2. The fulfilment of these sub-objectives in the study is linked to specific sections in this document, as presented in Table 10.2.

Table 10.2 Research objectives addressed in support of answering the second sub-research question

Research objectives	Section where reported
Objective 2.a To *discuss* the conceptualisation of the overall theory and the various components thereof.	Section 4.2
Objective 2.b To *analyse* and *document* trends in how the theory has been applied since it's proposal.	Section 4.4 Section 4.5
Objective 2.c To *identify* and *catalogue* a tangible set of evaluation concepts into an inventory based on the application of the theory in extant literature.	Section 4.5 Section 4.9

The evaluation concepts identified in this scoping review were catalogued into an evaluation concept inventory which was appropriately adapted and further built upon in pursuit of the final interactive tool.

The insights from answering the two SRQs contribute to answering the main research question which is discussed in the following section.

MRQ: How can the evaluation of clinic-based health information systems be supported by an interactive tool?

The findings generated through the process of answering the two SRQs provided a basis for further development of the interactive tool that is capable of answering the MRQ. To this extent, a number of additional research objectives were formulated and pursued in this study. The fulfilment of these research objectives in the study is linked to specific sections in this document, as presented in Table 10.3.

Table 10.3 Research objectives addressed in support of answering the main research question

Research objectives	Section where reported
Objective 3. To iteratively *develop* and *evaluate* multiple tool components using appropriate methods	Chapter 5 Chapter 6 Chapter 7
Objective 4. To *conceptualise* the interactive tool design that consolidates all of the interactive tool components established in fulfilment of Objective 3	Chapter 8
Objective 5. To *develop* and *build* an interactive tool using appropriate software. The interactive tool should be practical and user-friendly such as to fulfil the requirement identified in fulfilment of Objective 1.d	Chapter 8
Objective 6. To *demonstrate* the functionality of the interactive tool in the context of supporting the evaluation of clinic-based health information systems	Chapter 9
Objective 7. To *recommend* areas of future research related to this study that may be pursued in the future	Chapter 10

To answer the MRQ, the interactive tool provides three primary functional outputs which support the evaluation of CBHIS in various ways. Firstly, the *concept inventory* output supports evaluation by providing a tangible set of refined and contextualised evaluation concepts that may be considered to inform, or focus CBHIS evaluation efforts.

Secondly, the *responsive concept map* provides an interactive display of relationships between the evaluation concepts that form part of the concept inventory. This enables more comprehensive evaluation by allowing the tool users to consider how concepts are related and influence each other, thereby supporting the identification of additional pertinent concepts for evaluation purposes.

Finally, the *evaluation support document* which is generated based on a set of user defined inputs. The document contains the concept inventory, important contextual information as well as a set of ILEs that are compiled based on the user inputs. These ILEs provide a robust structure logical structure that incorporates the interrelated nature of the concepts and guides the application thereof to support evaluation.

The document supports evaluation in the same way the two, previous, functional outputs do but extends these in various ways. The ILEs included in the document systematically guides the identification of the pertinent concepts that may inform the appropriate and focussed formulation of the evaluation. Similar to the responsive concept map, the document contributes to a more comprehensive understanding of how different socio-technical aspects of the systems are related and thereby allows evaluators to take appropriate action by adding additional aspects to the evaluation or refining existing measures for the aspects under evaluation to best reflect the real-world scenario. Important contextual information specified by users in the initialisation of the interactive tool is presented in a useful manner in the document to support the accurate interpretation of findings. Finally, the ILEs and their application process contributes a more comprehensive understanding of what socio-technical aspects may be focussed on to improve potentially problematic areas.

10.4. Contributions and significance of this study

A number of contributions of this study are worth highlighting. This study demonstrates how knowledge from multiple domains may be synthesised into a useful artefact that addresses real-world problems.

10.4.1. Research domain contribution

The research contributes to the TTF literature in various ways. Firstly, by analysing and synthesising the literature through the published scoping review (Spies et al., 2020). Secondly, by presenting a novel application of the theory. Thirdly, by suggesting relationships between the concepts identified in TTF literature and thereby addressing the research gap that studies incorporate a large number of concepts related to the TTF theory but do not consider the relationships between these concepts (Section 4.6). Finally, this study demonstrates the utility of the theory to inform managerial decision about a system under consideration by adapting the theory based on the application environment. This addresses the research gap discussed in Section 4.6, that TTF related studies discuss the state of the phenomena under investigation and appropriateness of the TTF theory but lack discussions of the practical implications which may inform decision making. The demonstration of the theory's utility is also a contribution to the larger IS body of knowledge as it provides insight that additional IS theories, which aim to explain certain phenomena, may also be applied to inform real-world decision making by adapting these theories to the application environment.

This study also contributes to the M&E body of knowledge. Firstly, this study demonstrates how M&E knowledge and artefacts such as theories, frameworks, and methodologies may be synthesised and presented in a simple manner to support evaluation. Secondly, it provides insight into how existing knowledge from other domains may be leveraged to explain phenomena within the evaluation environment and thereby potentially improve the explanatory nature of the evaluation. Finally, it demonstrates how software may be leveraged to improve evaluations by capturing appropriate information, automating the processing of the information, and presenting the findings in a simple manner.

10.4.2. Methodological contribution

Furthermore, a methodological contribution to the DSR body of knowledge is made by this study. This is achieved by the publication of this thesis, which selected and applied the DSR framework. The general goal of the DSR approach selected in this study is to contribute knowledge in the form of an artefact to solve a real-world problem, specifically the interactive tool to support the evaluation of CBHIS. The knowledge contribution of the interactive tool developed in this study is positioned within the knowledge contribution framework suggested by Gregor and Hevner (2013) and described in terms of the types artefacts specified by Vaishnavi and Kuechler (2004, updated 2015), as depicted in Figure 10.2.

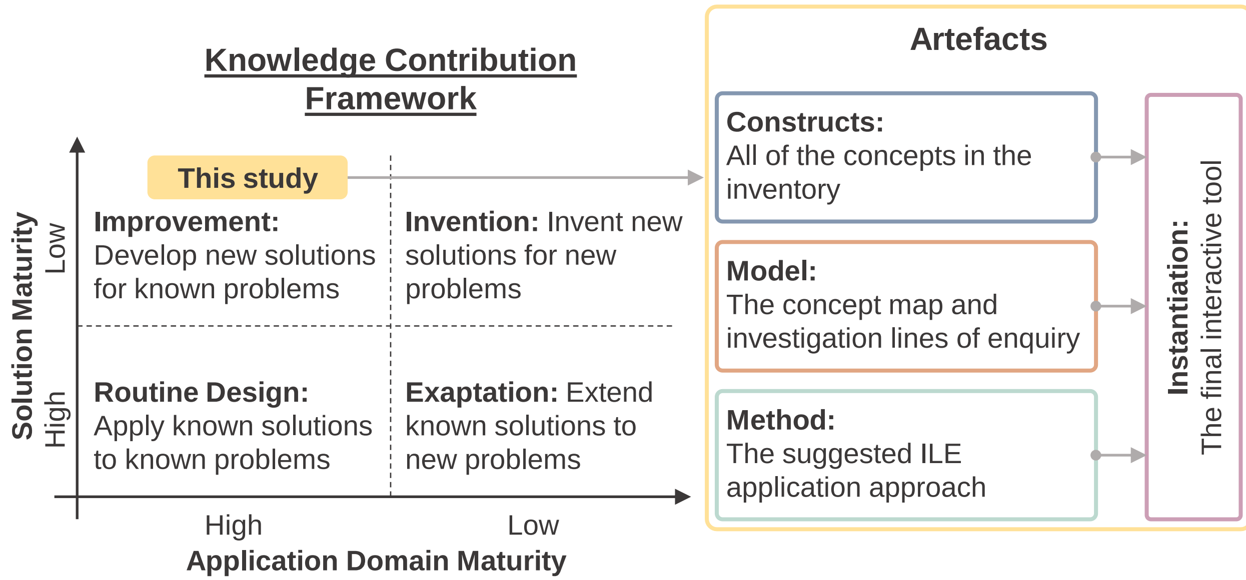


Figure 10.2 Knowledge contribution of this study (Gregor & Hevner, 2013; Vaishnavi & Kuechler, 2015)

The interactive tool developed in this study is an instantiation which realises evaluation concepts (constructs), the concept map and ILEs (models), and the suggested ILE application approach (methods) into a software product. The interactive tool provides a new solution for known problems like the need to support the evaluation of CBHIS, and is therefore considered an *improvement* based on the knowledge contribution framework.

10.4.3. Significance of the study

The final interactive tool consists of three primary outputs which support the evaluation of CBHIS. These components and their respective contributions are summarised in Table 10.4.

Table 10.4 Contribution of the interactive tool outputs to support the evaluation of CBHIS

Functional output	Contribution to support the evaluation of CBHIS
Concept inventory	The inventory provides a tangible set of refined and contextualised evaluation concepts that may be considered, to inform, or to focus CBHIS evaluation efforts, thereby answering the question *what socio-technical aspects should be considered?*
Responsive concept map	The relationships depicted between concepts in the concept map provide a means to consider the interrelated nature of the concepts help guide towards a more comprehensive evaluation of multiple socio-technical aspects of a system which influence each other. The interrelated nature of the concepts supports evaluation by providing an understanding of how concepts may influence each other and therefore answer the question *what else needs to be considered?*

Functional output	Contribution to support the evaluation of CBHIS
Evaluation support document	The evaluation support document synthesises both the former concepts and contextual information specific to the system under consideration. This ultimately supports evaluation by: 1. Systematically guiding the identification of pertinent concepts that may inform the appropriate and focussed formulation of the evaluation. 2. Contributing to a more comprehensive understanding of how different socio-technical aspects of the systems are related and thereby allowing evaluators to take appropriate action by adding additional aspects to the evaluation or refining existing measures for the aspects under evaluation to best reflect the real-world scenario. 3. Providing important contextual information for an accurate interpretation of the findings. 4. Providing a comprehensive understanding of what socio-technical aspects may be focussed on to improve potentially problematic areas.

Overall, the interactive tool indirectly contributes to SDG 3, viz. *good health and well-being for people*, through the support of these evaluations. This is achieved by providing adequate information for decision making purposes, thereby contributing to focussed, high-quality evaluation efforts. These evaluations allow socio-technical problems to be identified and mitigated as well as allows the identification of aspects that work which may be disseminated for general improvements in the system. The improvements to CBHIS contribute to more effective management and decision making across the entire PHC system which enables superior health care delivery and therefore contributes to *good health and well-being for people.*

10.5. Limitations of the study

In critically reflecting on this study, the researcher acknowledges certain limitations to the research approach and findings.

The initial set of evaluation concepts that were catalogued into the evaluation concept inventory were identified through the analysis of selected studies which applied the TTF theory. Only the Scopus database was used to identify relevant peer reviewed articles for the study using predefined search criteria. Various measures were taken to ensure that all influential studies potentially missed in the search were included in this study but the researcher acknowledges that additional studies of relevance may be identified by expanding the search terms, using multiple databases and considering grey literature.

A screening criteria for identifying relevant literature was formulated to ensure the reliability and replicability of the process. The researcher acknowledges that the actual selection of these studies may however be biased and that the exclusion of studies also excludes concepts of potential relevance. The content analysis of the included studies, specifically the identification of the evaluation concepts, was performed by the researcher alone and bias may be present in the researcher's interpretation of the content.

Furthermore, the initial set of evaluation concepts identified is limited to the TTF theory. Although this theory was found to be appropriate for this study (Section 4.8), the analysis of alternative artefacts may result in the identification of additional concepts.

The limitations associated with the initial set of evaluation concepts are however mitigated through the research design selected in this study; concepts were iteratively evaluated, incorporating additional data collection methods, namely the theoretical case study and multiple subject-matter expert reviews. These evaluations therefore allowed the set of evaluation concepts to be appropriately refined and supplemented, thereby mitigating the risk of excluding important and relevant concepts.

The relationships suggested between the evaluation concepts was based on the researcher's interpretation and may therefore be limited. The multiple evaluations of these relationships, which resulted in only minor modifications, aimed to mitigate this limitation but the researcher acknowledges that additional relationships may exist.

The theoretical case study considered a single case with only two relevant resources which were interpreted by only one researcher. Increasing the cases, exploring more resources and allowing multiple researchers to interpret the case study may result in additional, relevant evaluation concepts being identified. This limitation was mitigated by the refinement of existing evaluation concepts and inclusion of additional in the SME interviews conducted in the subsequent design cycle iterations.

Due to time constraints, only four SMEs were identified based on their domain expertise of relevance to this study. Increasing the number of SMEs may result in additional insights for the concepts, relationships and further development of the interactive tool. The SMEs were interviewed (Chapter 6) to evaluate the interactive tool components and review the ILEs (Chapter 7). Due to the large number of concepts and relationships, not all of these were discussed in the interviews. The SMEs were however provided with the complete set of evaluation concepts and relationships to evaluate such as to ensure that all are evaluated. The interview findings and subsequent changes to the interactive tool were also subject to the researcher's interpretation which may result in bias. The iterative evaluation approach aimed to mitigate this limitation by progressively evaluating the various components after changes were made.

10.6. Suggested future work

Several opportunities to expand and improve the contributions of this study were identified in the execution of the research and are discussed in the following sections.

10.6.1. Adaptations for generic tool use

Although the interactive tool developed in this study aims to support the evaluation of CBHIS, it holds the potential to support the evaluation of other IS outside the PHC environment. The interactive tool developed in this study processes two primary data sources, namely the concept inventory and the set of relationships, to produce the various functional outputs which support evaluation. The processing of the data as well as the generation of the outputs is completely generic in nature. Therefore, only the concept inventory and the relationships influence the direct contextual relevance of the interactive tool developed in this study.

The initial set of evaluation concepts were identified out of the TTF literature, in which the concepts were applied in numerous contexts, and added to an evaluation concept inventory. To ensure the relevance to this study, these concepts were therefore refined, contextualised and supplemented and the relationships between the concepts established to ensure their relevance to the CBHIS environment. Future work may therefore draw from the value of this tool in multiple ways.

Firstly, to apply the interactive tool in an alternative yet specific context, the initial evaluation concept inventory may be appropriately contextualised, and the relationships established based on the context. These may then be used by the interactive tool to generate the various outputs. Alternatively, evaluators may define their own set of context-specific concepts and the relationships between the concepts from which the interactive tool may generate the outputs.

Secondly, a more generic approach may be taken in which general evaluation concepts may be considered in the concept inventory, and general relationships may be suggested between these concepts. Since the evaluation concept inventory consists of concepts from diverse contexts, these concepts may provide the basis for the generic approach. Alternatively, evaluation concepts and relationships independent of the evaluation concept inventory may also be added.

Finally, the interactive tool may be further developed to be dynamic in nature, such as to allow freedom for users to explore any of the former suggestions. This may be achieved by developing the capability for users to add or remove concepts, modify concept descriptions, and establish appropriate relationships based on their needs.

10.6.2. Increasing the comprehensiveness of the interactive tool

The interactive tool developed in this study provides a high-level description of the various concepts incorporated in the interactive tool and requires the interactive tool users to further investigate the concepts based on their specific contexts. This may require further research on the concepts and selecting appropriate measures to determine the relevance of these concepts, depending on the familiarity of the concepts. Although this allows for the flexibility in the interactive tool's application, it may also result in the concepts being applied differently in the same context or possibly completely misinterpreted.

Future work may therefore pursue identifying and incorporating possible measures for each concept or provide more detailed suggestions on how the concepts may be investigated. The identification of such measures may also be used to expand the capability of the interactive tool by allowing users to input values for the measures and conduct appropriate analysis thereon.

Furthermore, two sets of relationships are suggested in this study, those related to information usage and data collection. The various parts of the interactive tool that utilises the relationship information considers these independently and rely on the user to identify pertinent concept in the alternative. In the PHC environment, the systems used by individuals on district, provincial or national levels consolidate information from multiple data collection based systems within the clinics. Pertinent concepts for information usage, such as the timeliness of data, is influenced by concepts related to the data collection, such as frequency of usage. Future work may therefore pursue to clarify the relationships between these two functions to provide more comprehensive insight and thereby better support evaluations.

10.6.3. Additional research suggestions

A number of additional research opportunities were identified, namely:

1. This study focused on the development of the interactive tool and did not apply the final tool within the environment. Further work may apply the interactive tool as part of a real-world evaluation of CBHIS. This may provide valuable feedback which aspects or phases of evaluation the interactive tool best supports. Additional practical guidelines may also be developed that guide users in how to incorporate and utilise the interactive tool within evaluations. Furthermore, the application of the interactive tool may be used to inform further tool modifications to improve its utility and enable better support.

2. As discussed in Section 10.5, the relationships suggested between the evaluation concepts was developed based on the application environment according to the researcher's interpretation. The opportunity exists for further research to explore and establish such relationships based on empirical work. This would further address the research gap identified in the TTF literature and contribute to more comprehensive applications of the TTF theory.
3. The interactive tool developed in this study demonstrates how knowledge from different domains may be synthesised and presented in a simple manner, allowing individuals to utilise this knowledge without the need for extensive background or expertise therein. The opportunity exists for studies to pursue similar intents, namely, to develop useful artefacts that synthesise domain knowledge and present it in a simple, easy to use manner.
4. The three cycle DSR framework was selected in this study to inform the research design, consisting of relevance, rigour and design cycles. The four cycle DSR framework suggested by Dreschler and Hevner (2016) considers an additional *change and impact* cycle which considers the effect of the DSR project on the wider external environment. Future work may consider the effect of the interactive tool developed in this study on the wider external environment as the interactive tool is applied to support evaluation.

10.7. Personal reflections

"*Scientific research is one of the most exciting and rewarding of occupations. It is like a voyage of discovery into unknown lands, seeking not for new territory but for new knowledge. It should appeal to those with a good sense of adventure.*" - Frederick Sanger

The voyage imagery used by Frederick Sanger deeply resonated with me in reflecting on my experience completing this study. I started this study in 2019 with excitement and naïve enthusiasm which lasted only a few months until I had to clarify what I aim to achieve in the study.

I struggled to remain within the scope of this and wandered off countless times into new research areas I found interesting. Although this posed some challenges, the weeks spent drawing pictures on the whiteboards at the department, cutting out pieces of paper with ideas, and packing them out across the research group's office resulted in the execution of a study I am proud of.

The experience has been invaluable, and I have been shaped in more ways than I expected. Through the process I have discovered more about myself, the world and what I regard as my role therein. I also faced certain challenges in the pursuit of completing this study. One of the biggest challenges learning to make decisions with little information, a lot of intuition and then be confident in my execution thereof.

I set out to complete a rigorous study which required practicing both resilience and endurance. The internal processing of the challenges I faced in the study also helped establish the truth that my identity does not depend on my performance.

Furthermore, the execution of this study has better equipped me to explore a large and wide range of information, identify that which is of relevance, analyse it, and synthesise it in a way that is useful for its application. I cherish this skill and believe that it is of great value in our society.

I am grateful for the privilege of completing this study and all the experiences that came with it.

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APPENDIX A. Complete set of articles included in the scoping review

The full set of articles which met the inclusion criteria in the scoping review (see Chapter 4) is presented in Table A.1.

Table A.1 Articles included in the scoping review

Authors	Title	Reference
Goodhue D.L., Thompson R.L.	Task-Technology Fit and individual performance	(Goodhue & Thompson, 1995)
Goodhue D.L.	Development and measurement validity of a Task-Technology Fit instrument for user evaluations of Information Systems	(Goodhue, 1998)
Gebauer J., Shaw M.J.	Success factors and impacts of mobile business applications: Results from a mobile e-procurement study	(Gebauer & Shaw, 2004)
McGill T.J., Klobas J.E.	A Task-Technology Fit view of learning management system impact	(McGill & Klobas, 2009)
Lee C.-C., Cheng H.K., Cheng H.-H.	An empirical study of mobile commerce in insurance industry: Task-Technology Fit and individual differences	(C. C. Lee & Cheng, 2007)
Goodhue D.L., Klein B.D., March S.T.	User evaluations of IS as surrogates for objective performance	(Goodhue et al., 2000)
Staples D.S., Seddon P.	Testing the technology-to-performance chain model	(Staples & Seddon, 2005)
Zigurs I., Buckland B.K., Connolly J.R., Vance Wilson E.	A Test of Task- Technology Fit Theory for Group Support Systems	(Zigurs et al., 1999)
Dishaw M.T., Strong D.M.	Supporting software maintenance with software engineering tools: A Computed Task-Technology Fit analysis	(Dishaw & Strong, 1998b)
Tam C., Oliveira T.	Understanding the impact of m-banking on individual performance: DeLone & McLean and TTF perspective	(Tam & Oliveira, 2016)
Chang H.H.	Intelligent agent's technology characteristics applied to online auctions' task: A combined model of TTF and TAM	(Chang, 2008)
Dishaw M.T., Strong D.M.	Assessing software maintenance tool utilization using Task-Technology Fit and fitness-for-use models	(Dishaw & Strong, 1998a)
Cane S., McCarthy R.	Analyzing the factors that affect Information Systems use: A Task-Technology Fit meta-analysis	(Cane & McCarthy, 2009)

Authors	Title	Reference
Liu Y., Lee Y., Chen A.N.K.	Evaluating the effects of task-individual-technology fit in multi-DSS models context: A two-phase view	(Liu et al., 2011)
Pelzer P., Arciniegas G., Geertman S., Lenferink S.	Planning Support Systems and Task-Technology Fit: a Comparative Case Study	(Pelzer et al., 2015)
Gebauer J., Tang Y.	Applying the theory of Task-Technology Fit to mobile technology: The role of user mobility	(Gebauer & Tang, 2008)
Pendharkar P.C., Khosrowpour M., Rodger J.A.	Development and testing of an instrument for measuring the user evaluations of information technology in health care	(Pendharkar et al., 2001)
Ioimo R.E., Aronson J.E.	Police Field Mobile Computing: Applying the Theory of Task-Technology Fit	(Ioimo & Aronson, 2004)
Hsiao J.-L., Chen R.-F.	An investigation on Task-Technology Fit of mobile nursing Information Systems for nursing performance	(Hsiao & Chen, 2012)
Lepanto L., Sicotte C., Lehoux P.	Assessing Task-Technology Fit in a PACS upgrade: Do users' and developers' appraisals converge?	(Lepanto et al., 2011)
Rivera M., Croes R., Zhong Y.	Developing mobile services: A look at first-time and repeat visitors in a small island destination	(Rivera et al., 2016)
Yang H.-D., Kang S., Oh W., Kim M.S.	Are all fits created equal? a nonlinear perspective on Task-Technology Fit	(H. D. Yang et al., 2013)
Glowalla P., Sunyaev A.	ERP system fit – An explorative task and data quality perspective	(Glowalla & Sunyaev, 2014)
Yi Y.J., You S., Bae B.J.	The influence of smartphones on academic performance: The development of the technology-to-performance chain model	(Yi et al., 2016)
Cady R.G., Finkelstein S.M.	Task-Technology Fit of video telehealth for nurses in an outpatient clinic setting	(Cady & Finkelstein, 2014)
Raven A., Le E., Park C.	Digital video presentation and student performance: A task technology fit perspective	(Raven et al., 2010)
Ali S.B., Romero J., Morrison K., Hafeez B., Ancker J.S.	Focus Section Health IT Usability: Applying a Task-Technology Fit Model to Adapt an Electronic Patient Portal for Patient Work	(Ali et al., 2018)
Melchor-Ferrer E., Buendía-Carrillo D.	Financial information management for university departments, using open-source software	(Melchor-Ferrer & Buendía-Carrillo, 2014)

Authors	Title	Reference
Kim S.K., Park M.J., Ahn E.J., Rho J.J.	Investigating the role of Task-Technology Fit along with attractiveness of alternative technology to utilize RFID system in the organization	(S. K. Kim et al., 2013)
Howard M.C., Rose J.C.	Refining and extending task–technology fit theory: Creation of two task–technology fit scales and empirical clarification of the construct	(Howard & Rose, 2018)
Huang L.-C., Shiau W.-L., Lin Y.-H.	What factors satisfy e-book store customers? Development of a model to evaluate e-book user behavior and satisfaction	(Huang et al., 2017)
Chen P.-S., Yu C.-J., Chen G.Y.-H.	Applying Task-Technology Fit Model to the Healthcare Sector: a Case Study of Hospitals' Computed Tomography Patient-Referral Mechanism	(P. Chen et al., 2015)
Wang S.L., Lin H.I.	Integrating TTF and IDT to evaluate user intention of big data analytics in mobile cloud healthcare system	(Wang & Lin, 2019)
Bere A.	Applying an extended Task-Technology Fit for establishing determinants of mobile learning: An instant messaging initiative	(Bere, 2018)

APPENDIX B. Initial evaluation concept inventory

In Table B.1 the full set of evaluation concepts identified in Chapter 4 is listed as the Evaluation Concept Inventory. The identifiers used in the table is based on the original association of the concept, as discussed in Section 4.9.

Table B.1 Initial evaluation concept inventory

ID	Evaluation concept	Description
TTF1	Ability to carry out tasks	Whether the technology enables the user to execute their tasks.
TTF2	Accessibility	Ease of accessing required information.
TTF3	Assistance	Ease of getting help on when problems or difficulties are encountered.
TTF4	Authorisation	User has the authorisation to access all the information that would be relevant in performing tasks.
TTF5	Compatibility	Information from different sources are easily consolidated without problems.
TTF6	Confusion	Information presented in a manner that makes it difficult to differentiate between different aspects thereof.
TTF7	Consulting	Availability of consulting services received from the technology.
TTF8	Contextual data quality	Data’s fitness for intended use.
TTF9	Currency	The information displayed is current enough to carry out tasks and presented in the required time.
TTF10	Ease of use	Ease of doing what is required.
TTF11	Familiarity	Acquaintance with the technology.
TTF12	Flexibility	Ability to make changes to the technology base on personal preference.
TTF13	Locatability	Ease of finding required information.
TTF14	Meaning	Ease of understanding what different aspects of the information means.
TTF15	Preference	Conceptualised in terms of the preference between a set of alternative technologies.
TTF16	Presentation	Information is presented in a useful manner.
TTF17	Production timeliness	IS is able to adhere to production schedule.
TTF18	Reliability	Whether the user displays confidence in the information presented by the technology.
TTF19	Responsiveness	Time taken to respond to requests made by the user for assistance, changes or services.
TTF20	Right data	The information presented for the tasks that need to be performed is correct.
TTF21	Right level of detail	The information is displayed at a sufficient level of detail.
TTF22	Satisfaction	Meet or exceed the expectations that the user has of the technology.
TTF23	Specific to task	Conceptual match between the task and technology characteristics.
TTF24	Synchronisation	Information exchange between systems takes place frequently enough for effective decision making.

ID	Evaluation concept	Description
TTF25	Systems reliability	Dependability and consistency of system up time.
TTF26	Tech Interest and Dedication	Extent to which IS takes business problems seriously.
TTF27	Tech performance	Extent to which the IS meets the service level agreements.
TTF28	Tech understanding of business	Extent to which IS understands the organisation's objectives/mission.
TTF29	Training	Availability of training when required.
TaC1	Complexity	The extent of complication inherent in a task.
TaC2	Difficulty	The need for particular skills or much effort to accomplish a task.
TaC3	Frequency	The rate at which a task is repeatedly performed.
TaC4	Immediacy	The need to suddenly perform a task without delay.
TaC5	Interdependence	The extent to which a task both depends on other tasks and has other tasks depending on it.
TaC6	Mobility	The extent to which the task can be performed without being limited to a particular setting.
TaC7	Non-routineness	The extent to which a task does not follow a regular procedure.
TaC8	Structuredness	The extent to which a task is clearly defined, able to be executed without requiring judgement.
TeC1	Adaptivity	The extent to which the technology can be modified for alternative use.
TeC2	Autonomy	The extent to which the technology can execute tasks without direct human initiation.
TeC3	Communication	The ability of the technology to enable communication.
TeC4	Non-functional attributes	Components of the technology which contribute indirectly to the usage (such as processing power).
TeC5	Portability	The extent to which the technology can be carried around and used in different environments.
TeC6	Rationality	The extent to which the technology provides data-based support for decision making.
TeC7	User support	The extent to which assistance is available for users of the technology.
U1	Choice	Whether an individual chooses to use the technology or not.
U2	Duration	The length of time that the technology is used per instance.
U3	Frequency	How often the technology is used in a specified period.
U4	Intention to use	The user’s opinion on whether there is an intention to use the technology.
U5	Perceived dependence	The user’s attitude towards the extent of dependence on the technology.
U6	Usage proportion	A calculated value of the number of times the technology is used to perform a task over the total number of times a task is performed.

APPENDIX C. Final evaluation concept inventory

The final set of evaluation concepts incorporated in the interactive tool is presented as the evaluation concept inventory in Table C.1. The initial set of concepts were identified through the scoping review discussed in Chapter 4. As discussed in Chapter 5 and Chapter 6, a number of evaluation concepts were removed and individual evaluation concepts were refined and contextualised based on findings from the application environment. Furthermore, evaluation concepts were added to the inventory based on the application environment.

Table C.1 indicates which concepts were modified or added along with the corresponding chapter in which this took place.

Table C.1 Evaluation concept inventory

ID	Evaluation Concept	Description	Modified in	Added in
TTF1	Ability to carry out tasks	The system empowers the user to execute their tasks.	Ch5	
TTF2	Accessibility	The system provides the user ease of access to required information.	Ch5	
TTF3	Assistance	Ease of getting help when problems or difficulties are encountered and being provided with feedback when a request is logged.	Ch6	
TTF4	Authorisation	User has the authorisation to access all the information on the system that would be relevant for performing tasks.		
TTF5	Compatibility	The system is easily integrated with others such that the information from different sources are easily consolidated.	Ch6	
TTF6	Clarity	Information presented in a manner that makes it easy to differentiate between different aspects thereof.	Ch6	
TTF9	Currency	The information displayed by the system is current enough and presented in the required time for the user to perform required tasks.	Ch5	
TTF10	Ease of use	The user finds the system easy to use and easy to perform tasks on the system.	Ch5	
TTF11	Familiarity	The user's acquaintance with, and comfortability in using, the system.	Ch5	
TTF12	Configurability	The user is able to make changes to the system according their personal preferences.	Ch6	
TTF13	Locatability	The information required by the user is easily found on the system.	Ch5	
TTF14	Meaning	The user finds all of the aspects of information provided by the system meaningful.	Ch5	
TTF16	Presentation	The way in which the system presents the information is useful (eg. Graphs rather than text).	Ch5	

ID	Evaluation Concept	Description	Modified in	Added in
TTF18	Reliability	The user displays confidence in the information presented by the technology.		
TTF20	Right type of information	The correct type of information is presented to the user for the tasks that need to be performed.	Ch5	
TTF21	Right level of detail	The information is displayed at a sufficient level of detail for the user to perform their required tasks.	Ch5	
TTF22	Satisfaction	The technology meets or exceeds the expectations that the user has of the system and the user perceives the value of using the technology to perform tasks.	Ch5	
TTF24	Synchronisation	The exchange of information to and from the system takes place frequently enough for information to be available when required.	Ch6	
TTF25	Systems Reliability	The dependability of the system and consistency of time that the system is fully functional.	Ch5	
TTF29	Training availability	System related training is available to users when required.	Ch5	
TaC1	Complexity	The extent of complication inherent in a task.		
TaC2	Difficulty	The need for particular skills or much effort to accomplish a task.		
TaC3	Task Frequency	The rate at which a task is repeatedly required or expected to be performed.		
TaC4	Immediacy	The need to suddenly perform a task without delay.		
TaC5	Interdependence	The extent to which a task both depends on other tasks and has other tasks depending on it.		
TaC7	Non-routineness	The extent to which a task does not follow a regular procedure.		
TaC8	Structuredness	The extent to which a task is clearly defined, able to be executed without requiring judgement.		
TeC2	Autonomy	The extent to which the technology can execute tasks without direct human initiation.		
TeC4	Auxiliary attributes	The various components of the system that contribute indirectly to its performance (such as processing power or screen brightness) is sufficient.	Ch6	
TeC5	Portability	The extent to which the system is usable in different environments.	Ch5	
U3	Usage Frequency	How often the system is actually used in a specified period by the user to perform relevant tasks.	Ch5	
U4	Intention to use	The user's opinion on whether there is an intention to use the system.		
U5	Perceived dependence	The user's attitude towards the extent of dependence on the system to perform their tasks.	Ch5	
AC1	Value perception	The users understand the system wide value of the system and the contribution of their respective tasks.		Ch5

ID	Evaluation Concept	Description	Modified in	Added in
AC3	Completeness	The extent to which all of the required information is captured on the system by the user.		Ch5
AC4	Timeliness of data	The extent to which information was submitted by the user on the system before predefined deadlines.		Ch5
AC5	Internal consistency	The coherence of the information in the system.		Ch5
AC6	External consistency	The level of agreement between the information on the system with other externally available information.		Ch5
AC7	Training quality	The training provided to users is standardised, comprehensive and easy to understand.		Ch5
AC8	Interoperability	The ability of the system to work together with other systems within and across organisational boundaries.		Ch6
AC9	Training utilisation	The actual utilisation of available training opportunities by users.		Ch6

APPENDIX D. Relationships between evaluation concepts

The relationships between the evaluation concepts are introduced in Section 5.5 and further refined as a result of the findings from the SME expert interviews discussed in Chapter 6. There were 118 relationships associated with *information usage* related tasks and 61 relationships associated with *data collection* related tasks.

As discussed in the Chapter 5, the relationships may be presented in a tabular format or as a concept map indicating the related concepts and the nature of the relationship. Due to the large number of relationships, and the complexity in visualising this in a concept map, the representation thereof within the document posed a challenge. The final set of relationships for both task types depicted in both a tabular format and concept map may be accessed at: https://bit.ly/2IK32c9.

APPENDIX E. Overview of discussion guideline for semi-structured interviews

Semi-structured interviews were conducted with multiple SMEs (Chapter 6) and the guidelines were adjusted based on the interviewee. The overall structure of the interviews was the same, with differences in the discussion based on their respective environments. These are presented in Table E.1.

Table E.1 Overview of semi-structured interviews

Step	Overview of how questions were structured		
	TTF experts	M&E of CBHIS	CBHIS development
Introduction and background	Introduction to the researcher and the study was provided. Consent was obtained from the participants.		
Introductory questions	Establish the relevance of the participants and understand their exact background to inform how further questions may be presented or explained.		
Discussion questions	• Appropriateness of TTF application. • Confirmation or required adaptations to the evaluation concepts. • Confirmation or required adaptations to the suggested relationships between the evaluation concepts. • Discussion around how these may be presented to ensure utility in meeting the aim of the study.	• Discussion around how evaluation of CBHIS is done in SA PHC. • Confirmation or required adaptations to the evaluation concepts. • Confirmation or required adaptations to the suggested relationships between the evaluation concepts. • Discussion around how these may be presented to ensure utility in meeting the aim of the study.	• Discussion around how the systems developed by their company is evaluated internally and externally. • Confirmation or required adaptations to the evaluation concepts. • Confirmation or required adaptations to the suggested relationships between the evaluation concepts. • Discussion around how these may be presented to ensure utility in meeting the aim of the study.
Post review	Complete set of evaluation concepts and relationships were sent through with set of questions forming part of the previous step and the SMEs provided feedback by email.		

APPENDIX F. Demonstration of concept map responsiveness

In this appendix, the responsiveness of the concept map in the final interactive tool is demonstrated. An initial base scenario is used as the reference from which the various parameters are altered one at a time (indicated by a circle in each figure), and the resulting output displayed.

Base scenario

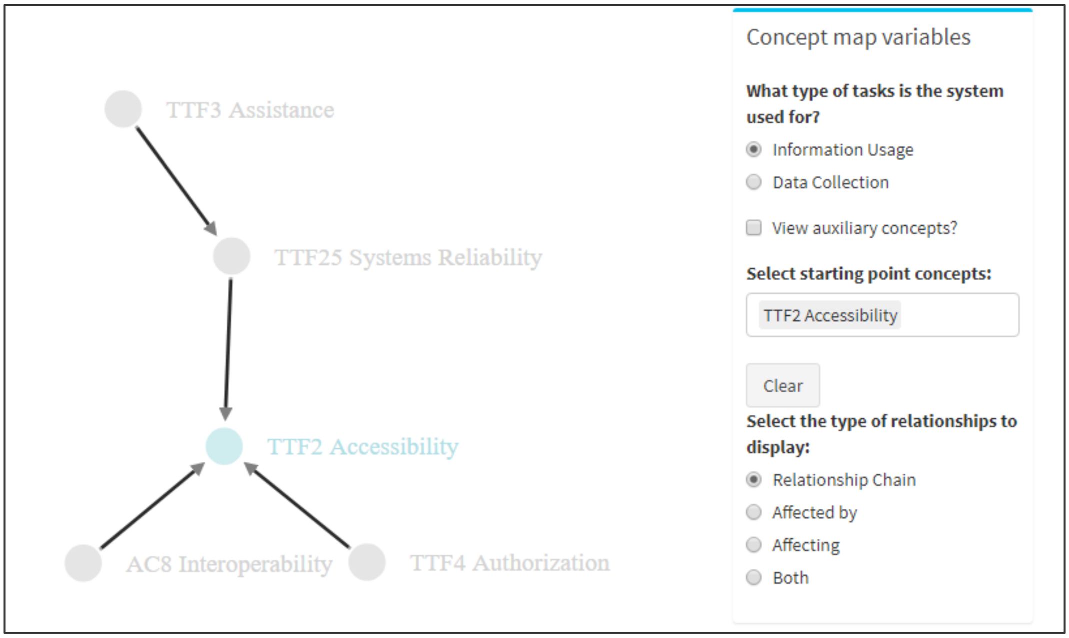


Figure F.1 Responsive concept map base scenario

Alternative task type

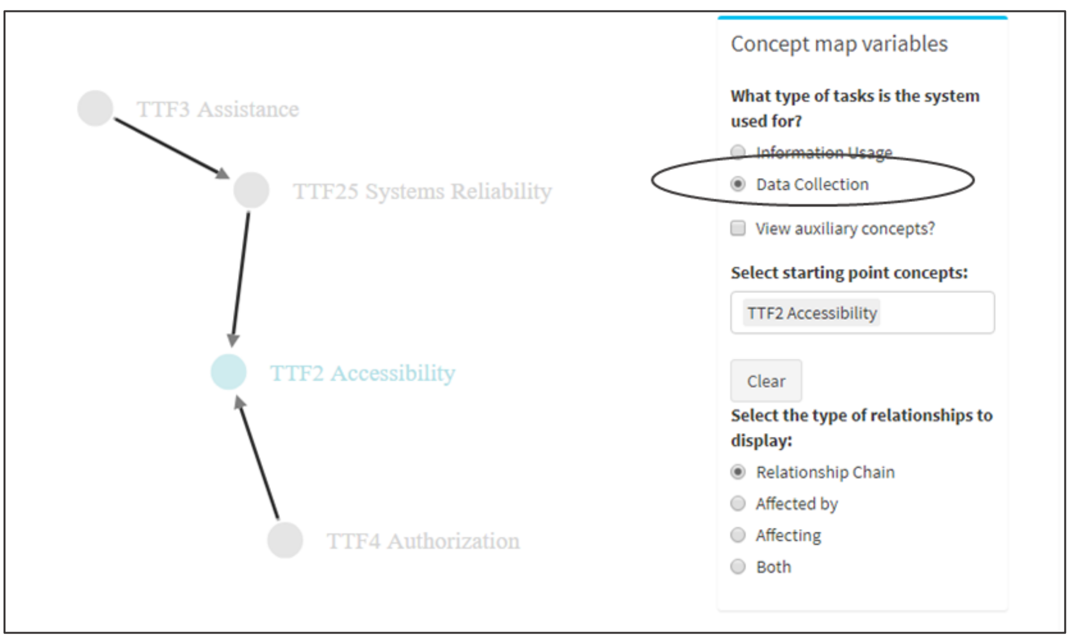


Figure F.2 Alternative task type

Display auxiliary concepts

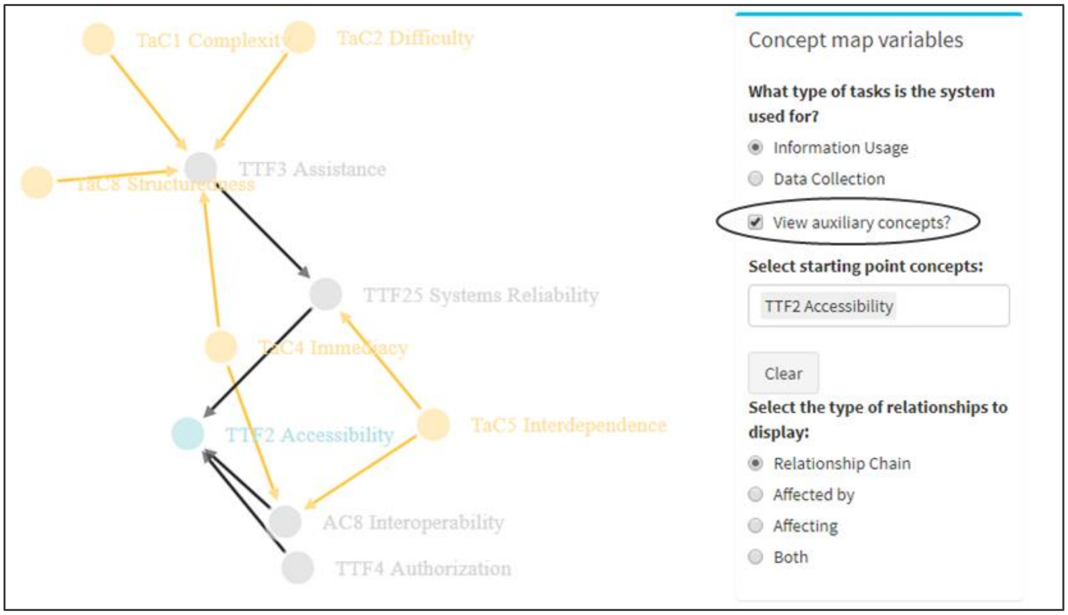


Figure F.3 Display of auxiliary concepts

Multiple starting points

Figure F.4 Selection of multiple starting points

Diff types of relationships

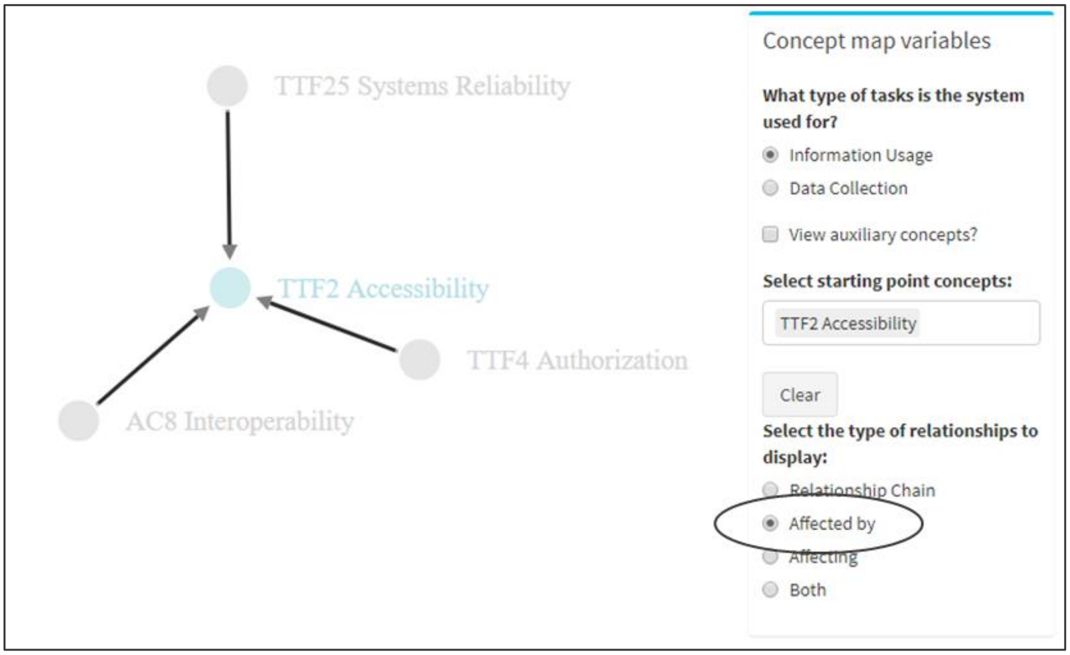


Figure F.5 Alternative relationship: Affected by

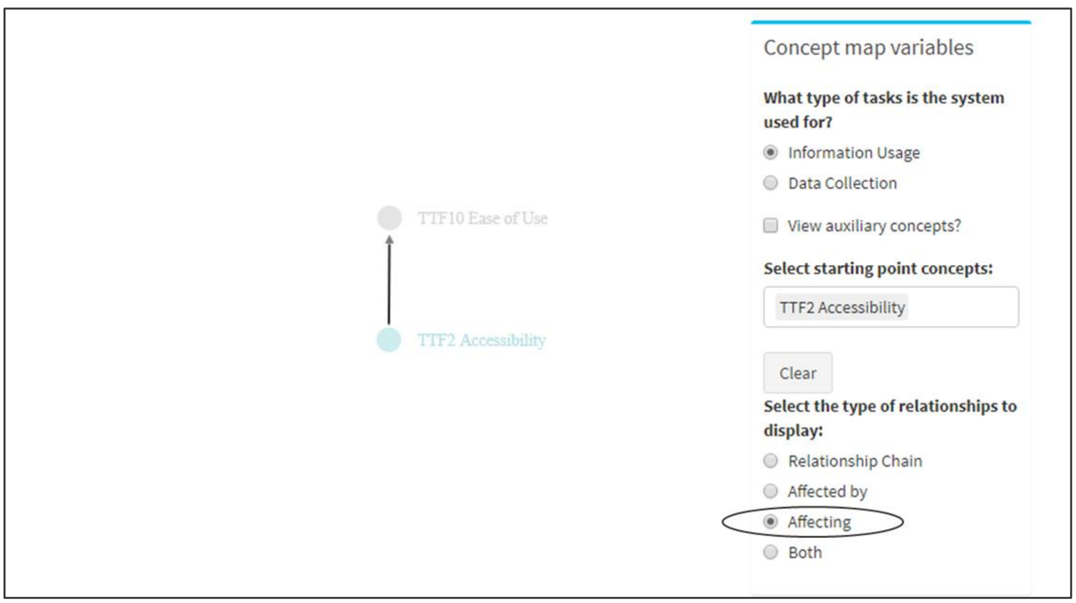


Figure F.6 Alternative relationship: Affecting

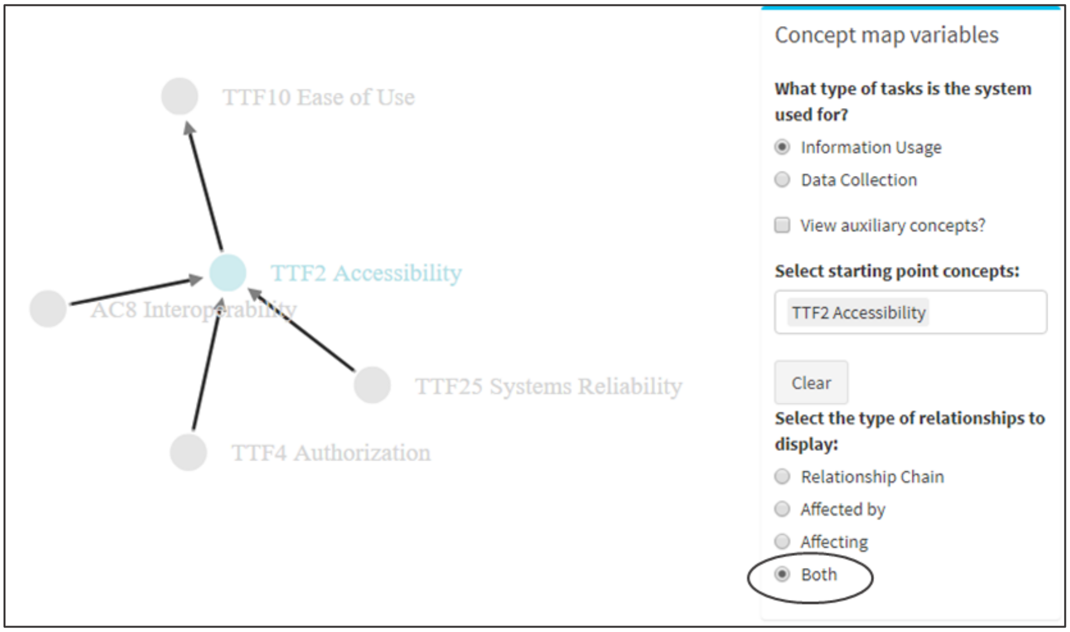
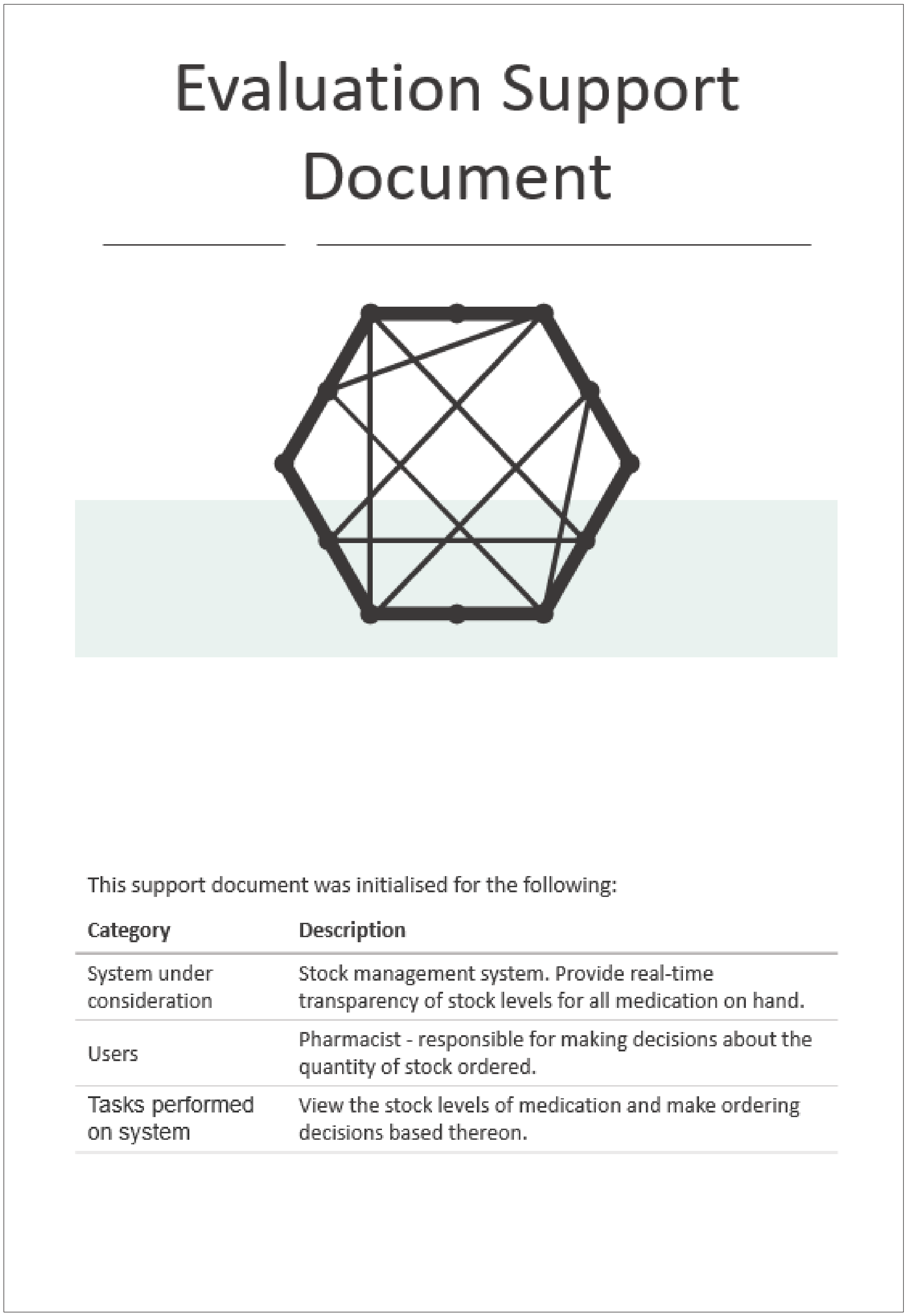


Figure F.7 Alternative relationship: Both affected by and affecting

APPENDIX G. Evaluation support document example

In this appendix, screenshots from the evaluation support document generated from an example scenario discussed in Section 9.4.4 is displayed.



Evaluation Support Document

This support document was initialised for the following:

Category	Description
System under consideration	Stock management system. Provide real-time transparency of stock levels for all medication on hand.
Users	Pharmacist - responsible for making decisions about the quantity of stock ordered.
Tasks performed on system	View the stock levels of medication and make ordering decisions based thereon.

Figure G.1 Page 1: Evaluation support document cover page

Application Instructions

Document contents

Concept Inventory

The set of evaluation concepts that is used as a reference for the exploration of the ILEs and investigation of concepts.

Investigation lines of enquiry

A structure which provides a suggested, sequential order of investigation that is formulated by identifying an initial concept to be investigated and sequentially structuring all collective related evaluation concepts. The purpose of the ILEs is to identify a set of relevant concepts which may be used to inform more comprehensive evaluation

An infographic describing how these may be best understood and used is presented on the following page

Investigation lines of enquiry application guidelines

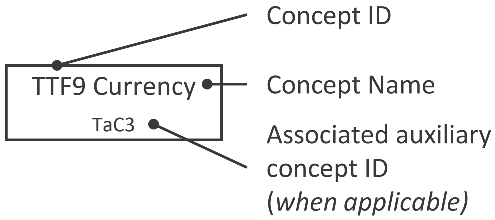
Exploration guideline 1: Investigate concept based on the concept description and determine the relevance of the concept based on system or evaluation context	The set of concepts included in the inventory all provide important considerations for evaluation. The presence of a concept in an ILE suggests its importance based on the selection of a starting concept. The concept description should aid to understanding what a concept refers to.
Exploration guideline 2: Where applicable, review the additional considerations provided by the auxiliary concepts	The presence of the auxiliary concepts identified in the initialisation phase prioritises certain descriptive concepts or provides a way to interpret these concepts. Specific attention should be given to concepts which are related to the applicable auxiliary concepts.
Exploration guideline 3: Determine concept pertinence for further evaluation based on system or evaluation context	The pertinence of concepts should be determined by the investigator based on the specific system, its context, and the evaluation context. If the concept description is found to be insufficient to identify the pertinence thereof, the investigator should use the description to guide the identification of more detailed measures that may be applied to determine the relevance.
Exploration guideline 4: If a concept is not found to be pertinent, then further related concepts do not need to be investigated	The ILEs provide a structured approach to identify consider concepts that are related to each other, and consequently may influence the state of the system. Therefore, if a concept is found to be irrelevant then the concepts that influence the concept under consideration do not need further investigation.
Exploration guideline 5: Consider related descriptive concepts and the type of relationship	The relationships between concepts may provide a greater understanding of factors that influence the functioning of the system. The influence of the related concepts should be considered based on the type of relationship and investigating the related concepts.
Exploration guideline 6: Use the concept relationships and ILE structure to guide the order of investigation.	The ILEs are structured sequentially based on the relationships between concepts. These may be used as a reference for ordering the investigation.

Figure G.2 Page 2: Application instructions

Application Instructions

Interpreting the investigation lines of enquiry

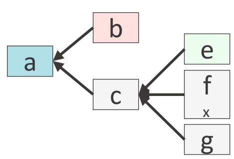
Concept labels



Concept colours

- Evaluation concept
- Selected starting point concept
- Point at which ILE is broken into new ILE
- Concept which forms part of a loop

Linear configurations



ILE structural interpretation:

- All concepts may be considered based on the description in the inventory
- *a* is the selected starting point
- *b* has further related concepts which may be explored in a following ILE
- *e* forms part of a loop and the subsequent radial ILE should be further investigated if of interest
- *f* is prioritised due to the tasks having characteristic *x*

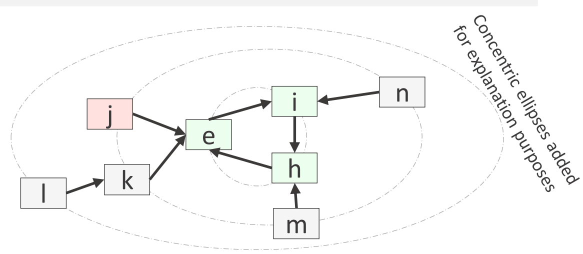
Relationships:

- *b* and *c* contribute to *a*
- *e*, *f* and *g* contribute to *c*

Suggested investigation order:

- Left to right due to relationships
- Consider concepts with associated task characteristics
- Additional concepts based on preference

Radial configurations



ILE structural interpretation:

- All concepts may be considered based on the description in the inventory
- *e, i* and *h* form part of the loop
- *j* has further related concepts which may be explored in a following ILE

Relationships: Same logic applied as with linear ILE configurations

Suggested investigation order:

- Concepts that form part of loop followed by next layer of concepts (illustrated by concentric ellipse)
- Consider concepts with associated task characteristics
- Additional concepts based on preference

Figure G.3 Page 3: Application instructions continued

Concept Inventory

The complete set of evaluatory concepts are listed in the table below. Use the instructions to guide how to use it and consider only those of relevance.

Concept	Description
TTF1 Ability to carry out tasks	The system empowers the user to execute their tasks.
TTF2 Accessibility	The system provides the user ease of access to required information.
TTF3 Assistance	Ease of getting help when problems or difficulties are encountered and being provided with feedback when a request is logged
TTF4 Authorization	User has the authorisation to access all the information on the system that would be relevant for performing tasks.
TTF5 Compatibility	The system is easily integrated with others such that the information from different sources are easily consolidated.
TTF6 Confusion	Information presented in a manner that makes it difficult to differentiate between different aspects thereof.
TTF9 Currency	The information displayed by the system is current enough and presented in the required time for the user to perform required tasks.
TTF10 Ease of Use	The user finds the system easy to use and easy to perform tasks on the system.
TTF11 Familiarity	The user's acquaintance with, and comfortability in using, the system.
TTF12 Configurability	The user is able to make changes to the system according their personal preferences.
TTF13 Locatability	The information required by the user is easily found on the system.
TTF14 Meaning	The user finds all of the aspects of information provided by the system meaningful.

Figure G.4 Page 4: Concept inventory

Investigation Lines of Enquiry

The investigation lines of enquiry were developed based on the scenario described in the following table:

Category	Description
System under consideration	Stock management system. Provide real-time transparency of stock levels for all medication on hand.
Users	Pharmacist - responsible for making decisions about the quantity of stock ordered.
Tasks performed on system	View the stock levels of medication and make ordering decisions based thereon.
Task Description	TaC4 Immediacy

The user specified that the task characteristics shown in the following table were relevant to the tasks performed on the system under evaluation. The investigation lines of enquiry provide a set of concepts to be considered based on their relationships. The prominence of these task characteristics result in certain concepts potentially having a higher priority. This may be demonstrated by the example, if tasks are urgent then the timeliness of the data is a higher priority than when not urgent. In the ILEs, the prioritised concepts are coloured yellow and the related ID(s) of task characteristic is specified.

Concept	Description
TaC4 Immediacy	The need to suddenly perform a task without delay.

The investigator selected the following concepts as starting points for the investigation lines of enquiry: TTF9 Currency, TTF18 Reliability

Additionally, the following concepts were used to split the investigation lines of enquiry such that a smaller number of concepts are shown per ILE: TTF1 Ability to carry out tasks, TTF10 Ease of Use, TTF11 Familiarity, TTF14 Meaning, TTF18 Reliability, TTF22 Satisfaction.

The investigation lines of enquiry generated for the for this scenario is displayed on the following page.

Figure G.5 Page 5: Investigation lines of enquiry

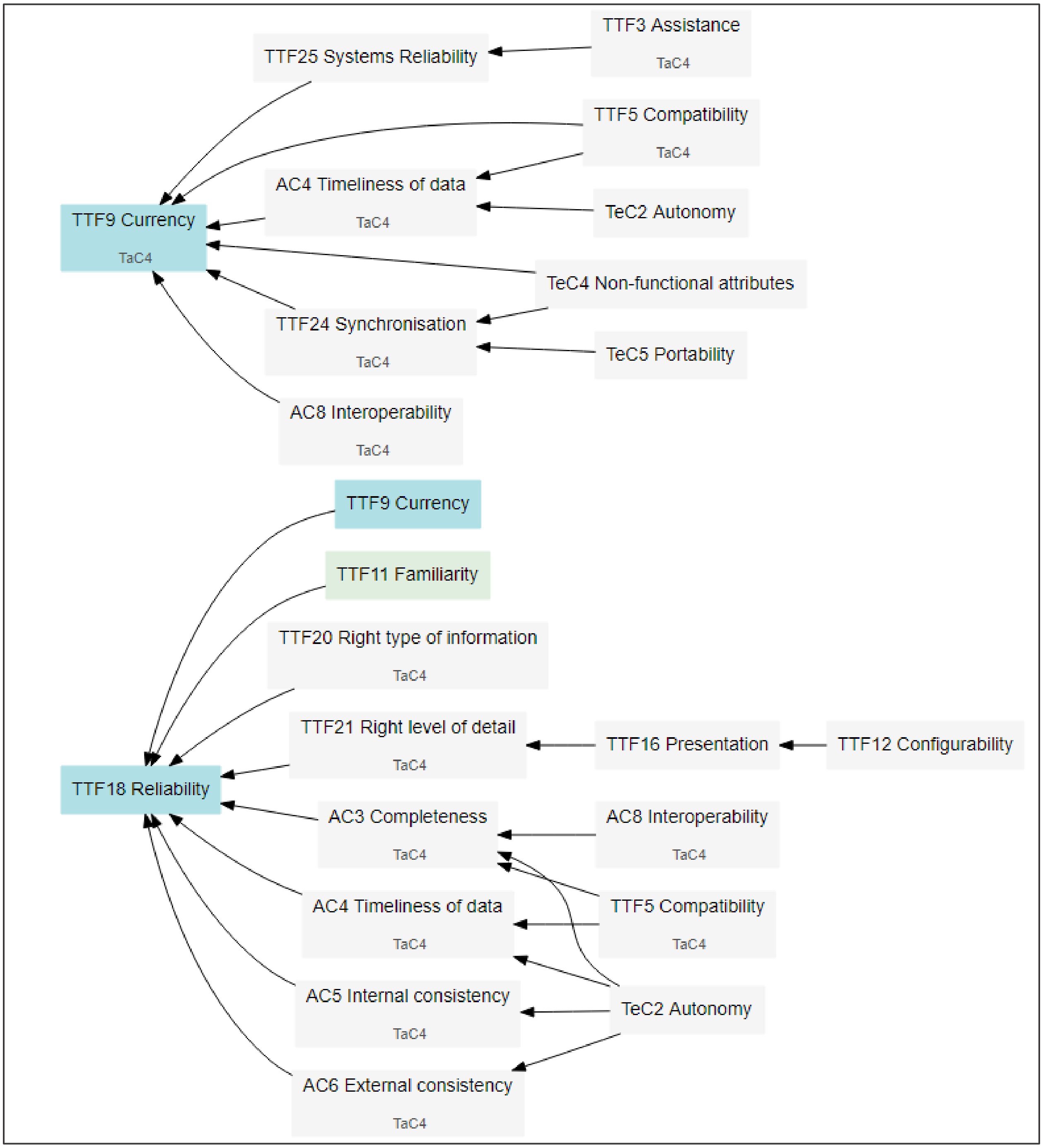


Figure G.6 Page 6: Investigation lines of enquiry continued

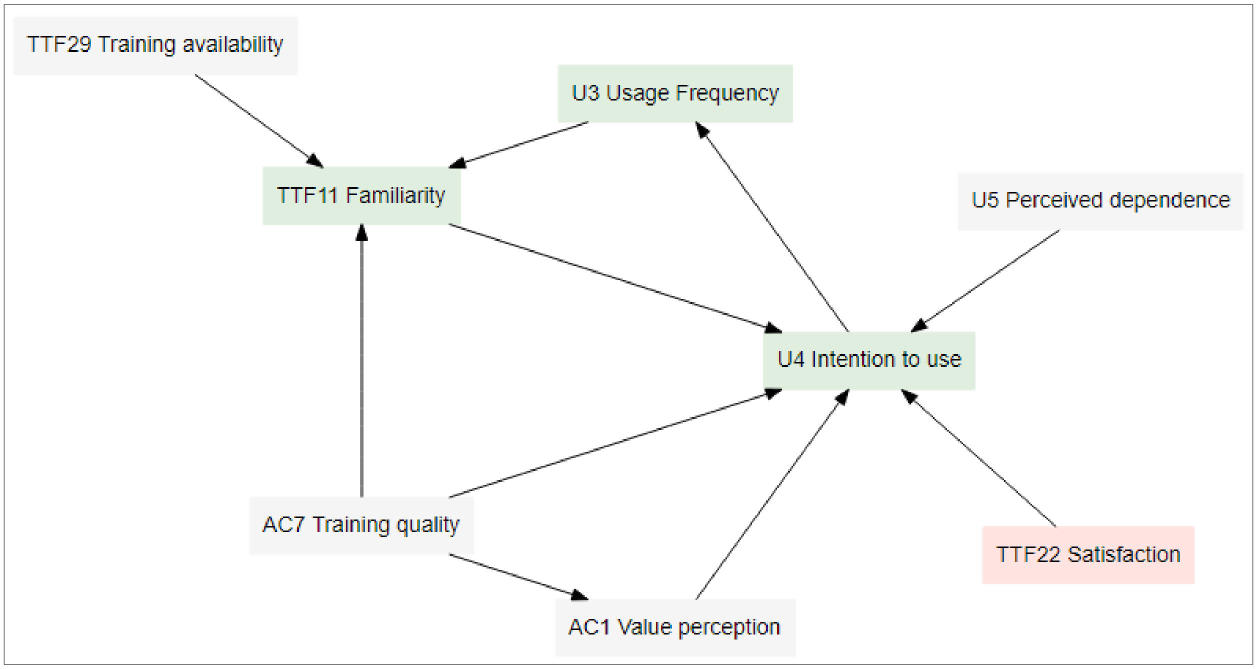


Figure G.7 Page 7: Investigation lines of enquiry continued

As shown in the final ILE, *TTF22 Satisfaction* is also a breakpoint. The ILEs resulting from this concept were however omitted from this appendix as the first three were found to be sufficient for demonstration purposes.