Design and Evaluation of Activities and Reference Model for the Meta-Design Phase of Design Science - Demonstrated on Business Process Model Artefacts

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Declaration

I hereby certify that this material, which I now submit for assessment on the programme of study leading to the award of Doctor of Philosophy is entirely my own work, that I have exercised reasonable care to ensure that the work is original, and does not to the best of my knowledge breach any law of copyright, and has not been taken from the work of others save and to the extent that such work has been cited and acknowledged within the text of my work.

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Abstract

Design science research is one of the distinctive approaches for Information Systems (IS) research projects in related literature over the last decade. Researchers proposed various methodologies and theories that elaborate on two of its key phases, *build* and *evaluate* the design science research artefacts. As substantial work has been done in relation to evaluation methods, the build phase is limited to provide and suggest only general directions that could be used for building design science artefacts. Design science research can reach its full potential impact on information systems projects by attaining gaps in the understanding and structure of its methodology.

This research identifies, analyses and combines existing design science methodologies to propose methods for a meta-design phase that guides design science researchers through construction a design science artefact and design theories that form the output of design science research in IS. The general activities of the meta-design phase are derived from building and evaluating a reference model. This model is an instantiated meta-design phase that focuses on building business process model artefacts. Its goal is to guide design science researchers through the build phase of design science methodology to achieve business process model artefacts. It incorporates principles, practices, and techniques required to build such artefacts in a form of a research process. It is consistent with prior literature, provides a nominal process model for doing design science research, and complies with design science methodology. The process of the reference model includes three main areas: literature review, collaboration with practitioners, and information modelling. The model is demonstrated and evaluated by presenting case studies concerning design science as the main research methodology, and experimental designs aiming at the perception of representational information quality of business process model artefacts.

The research pivotal contribution is identification and structure of the meta-design phase in design science research methodology by building and validating one of its instances, the reference model. In addition, the model provides researchers with choices of operational activities for building business process models in design science research paradigm

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1 Introduction

1.1 Overview

Concerning the whole tray of ideas involved what researchers are most impressed by—what they are evidently most interested in—is how the unseen accounts for the seen. Researchers wonder how indefinite motives generate define acts, how indefinite talent creates knowable innovative artefacts, entities that have some separate existence. Researchers, who have carried the load in philosophy, pointed out that there is required assistance in addressing these very varied and fascinating topics [1]. Innovative ideas are critical for companies and research institutions; however; the process of conducting and initiating innovation is challenging. What has been lacking from previous research is a formalisation of a detailed process to start from an idea and "design" to a valuable output. Researchers want to employ methodologies that make success more available—more frequent, consistent and correct.

Over the last number of years design science (DS) research methodology has received increased attention in computing and information systems (IS) research [2,3]. It has become an accepted approach for research in the IS discipline, with dramatic growth in recent related literature [4,5]. Views and recommendations on design science methodology vary among papers, e.g. [6,7,8]. However, there are concerns with their high-level of abstraction and lack of specificity [9,10]. Their application suggest that existing methodology is insufficiently clear or inadequately operationalized [7] for participatory design science. Descriptions of activities (procedures, tools, techniques) should account the practice.

This research examined some of the challenges associated with the application of the design science methodology. By focusing on a specific domain artefact, a business process model, methods and techniques are synthesized for its construction and hence additional activities are identified to contribute to design science research methodology.

To determine general set of activities which are necessary to build design science artefacts, this research postulates construction of a systematic research process in form of a reference model that serves design science researchers seeking for business process model artefacts and have a positive impact on their information representation. This contention that no much operational guideline is given for design science research process led to the main research motivation:

Examining and evaluating meta-design phase of design science to provide reference model for construction of business process model artefacts and determine its activities for generalization of this phase.

It is within this context this research was conducted. It involved the construction of a reference model (also referred in this work as the process oriented reference model) for which research practices were observed, gathered and then synthesised to build business process model artefacts. These form the output of this research. In conjunction with corporate partners various approaches were examined to outline the application of design science research for business process model artefacts. A practical application of the reference model was demonstrated and its utility was evaluated as an approach that can be employed to assist researchers with selection of research techniques. These contributions added to the knowledge and implementation of design science methodology, business process model frameworks in design science settings, and research evaluation.

1.2 Key Terms

A methodology is a collection of procedures, techniques, tools, and documentation aids which aim to help researchers in their efforts to carry out a new innovative research idea. A methodology would consist of phases, themselves consisting of sub-phases, which guide the researchers in their choice of techniques that might be appropriate at each stage of the research and also help them plan, manage, control and evaluate their work. A methodology is more than merely a collection of these things, it is usually based on some philosophical view; otherwise it would be merely a method, like a recipe [11].

In this research, design science refers to a research paradigm in information systems field that addresses research through the building and evaluation of artefacts designed to meet needs at the intersection of information technology and organization.

Literature indicates that artefacts can be understood as "things", i.e. entities that have some separate existence [12]. The artefact of this research is a reference model that guides design science researcher through construction of business process model artefacts at the meta-design phase of this methodology. The meta-design phase delivers a concluding activity summarizing results directed for target problems. Business process model artefacts, in this research, are business processes models in form of a collection of activities that takes one or more kinds of input and creates an output that is of value to the stakeholder. Methods are considered the practical realization of an approach, e.g. the design science methodology, whereas techniques are tools or skills coherent with a method, and therefore, they must be in harmony with the approach. In this research, the term activity refers to both methods and techniques as a set of prescribed actions or events that must be undertaken to achieve a certain result.

Literature review and collaboration with practitioners refer to sources from which activities for the reference model are obtained. They lead to build a knowledge base and review the critical points of current knowledge and/or methodological approaches on particular aspects of the model. The knowledge base in this research is a store of information that is available to draw on.

1.3 Motivation and Problem Statement

Widely cited scientific publications from IS field pointed to a need for a common design science methodology [13]. Archer's [14] methodology considers one aspect of DS research, which resulted in building system instantiations as the research outcome, or "the purposeful seeking of a solution" to a problem formulated from those desires [15]. Archer [14] believed that design could be consolidated, even the creative part of it. Through his work, he outlined six phases of DS research: to establish project objectives, collect data and analyse, synthesise the objectives and results, produce design proposals, prototype, and to communicate the results. With these phases, he asserted that designers can approach design problems "systematically," by looking at functional-level problems such as goals, requirements, and by progressing toward more specific solutions [16].

A number of researchers, both in and outside of IS discipline, have sought to provide some additional systematic guideline to define design science research [8]. Their work in engineering [12,17], computer science [18,19], and IS [20,18,21,22] have aimed to collect and distribute the appropriate reference literature [23]; characterize its purposes, differentiate it from theory building and testing research and from other research. However, beyond providing frameworks and ideas of what needs to be designed in the design science research, researchers provided very little guideline for the phases where the systematic construction of design science artefact takes place. This state of affairs in design science constitutes what one can call "a gap of construction activities in design science". This research responds to this gap by identifying meta-design phase and designing a reference model for it. The reference model guides researchers through the phase from its preparatory stage to the meta-design documentation, with choices of techniques and associated tools for each stage in the context of business process artefacts. Reference models promise higher quality of solutions at less cost [24]. They intend to provide appropriate descriptions of a solution for a domain. Most importantly, they are aimed at delivering blueprints for a distinctively good design for information systems projects and related research settings. They are not directly tied to any standards, technologies or other concrete implementation details, but they do seek to provide a common semantics that can be used unambiguously across and between different executions and implementations. In addition, the reference model should be capable not only to produce a high quality output, but also gather, represent, and reuse knowledge in a systematic way for business process model artefacts of design science research in information systems. In a domain context, that reflects the relevant knowledge based on domain-specific concepts and relations. In terms of design science, it provides a solid foundation on which sharable knowledge bases can be built for wider usability than that of a conventional knowledge base. Application of this model systemizes knowledge before an instantiation of an artefact [8] is being developed.

Thus, the contribution of the reference model is to introduce and demonstrate phases for construction of design knowledge in design science research methodology. The basic goal of the reference model is to be a collection of related, structured activities that help researchers investigate a research problem in IS field. This goal constitutes the definition of a research process [25]. However, this emerged a research challenge of how to conduct research process in design science context. Moreover, a single reference model is not capable to cover all spectra of design science research and their possible requirements at the operational level. To achieve information representation and applicability of the reference model, it should cover thoroughly one type of design science artefacts. The selection of this type of a business process model artefact was shaped by taking into account a few factors. By building a reference model in the form of a business process, process oriented techniques and methods, which may apply in constructing business process model artefacts, are investigated. The reference model then comprises the first instantiation of these process techniques and methods selected, and hence their validation could be demonstrated. Another factor was the interest of business process discovery that has been widely discussed in the IS community [26,27]; however, the emphasis has been put on discovering to improve current processes in an organization or a research domain, whereas the reference model considers creating new processes to meet requirements of innovation ideas.

On the other hand, there are IS researchers which have not focused on contributing to the development of a consensus process and model of design science research, such as those called for in engineering literature [28,17]. Some research work published in IS journals supports its validity by using information theory to justify the use of an IS planning method [29] or as a practical extension of another methodology [30]. In the work of Rothenberger and Hershauer [31], the work validity of the artefact to measure software reuse was conducted by evaluating using one project of the field company that is treated as a case study. Despite many citations, this lack of a consensus in design science research outlines the reason why design science research has not resulted in more research in IS that makes explicit use of the paradigm [32].

The identification and focus on the business process model aspects in this research emerged due to requirements of an industrial research project. The aim of the research project was to develop a management platform that combines business processes occurring in enterprises. The purpose of the platform was to provide knowledge about development, documentation and configuration of individual processes that can contribute to daily business operations. It was identified that information representation of these business process models can be of a good quality if they are determined in a systematic fashion. In this context it became evident that detailed design science methodology with the business process reference model will find its application there. Thus, for this research collaboration with business partners was established. In other words, it helped narrow down the research to business process oriented artefacts. There are varieties of other plausible design science research artefacts to which meta-design phase of design science should provide operational activities for researches. In this research, the meta-design phase of design science research is determined in the context of requirements of business process model artefacts. This constitutes the link between design theory of the reference model artefact and its business application (see Section 1.4). By fully constructing and evaluating a systematic approach for one type of design science artefacts in the meta-design phase, a general approach, to help design science researchers aiming at different meta-design artefacts, can be inferred. This constitutes the main research motivation. Last but not least aspect of this research was to embrace in the reference model how academia and business engage to achieve a common goal – a design science artefact.

One of approaches to methodology is to regard it as a human activity system, this enables to apply the same sort of quality criteria as one would apply to any such systems, including information systems themselves [33]. From these quality criteria, one can derive principles of methodology design, in terms of the quality characteristics expected of a good methodology. Hence, one aspect in evaluation of the reference model is towards quality of information representation to design science researchers and artefact users. The model is evaluated through various case-studies and experiments for which data was gathered and analysed during development of business process models. This research seeks to identify and develop tools to facilitate routines and/or semi-automate phases for the model.

An underlying research problem aims to fill in the above mentioned construction gap in the meta-design phase of design science research methodology by generalizing previously developed reference model. To develop the reference model, a design science research framework [8] is followed. Its general guideline and principles are employed to identify and detail the meta-design phase for development of design knowledge in this methodology. Focus groups and semi-structured interviews with the business partners are established, and systematic literature review is followed. Theory from other disciplines are applied, such as economics, computer science, and the social sciences at the intersection of information technology and organizations [7] to build the reference model. As the reference model is built on design science, it discloses activities than can be generalized and applied to broader range of design science artefacts. Figure 1.1 illustrates this research contribution to design science. Although the reference model is business process model-oriented, its structure and some of activities can be generalized and applied across domains.

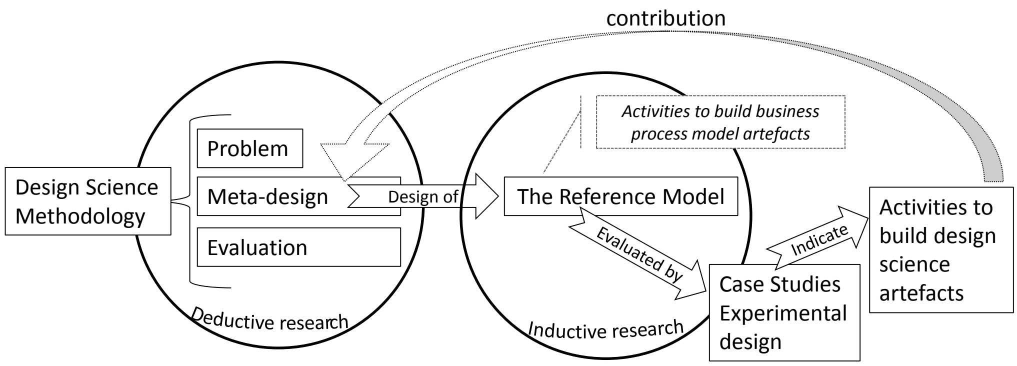

Figure 1.1: Contribution to Design Science

Motivation for DS research may additionally come from the business side [34] as it is in this case. In the following sub-sections, the business scenario, that underlines a need for a systematic research process which is satisfied by the reference model, is presented. The business scenario helped narrowed down specifications for the reference model and identified its key objectives. Hence, the motivation for this research in IS field is to serve both academia and organization.

1.4 Research Objectives

The modern organizational division for information technology has experienced significant transformations in most companies and across many industries. Despite the fact that Information Technologies (ITs) have long been acknowledged to bring a strategic advantage [35], the way of how IT enables competitive advantage and better performance has changed [36,37]. Three directions can be distniguished. One is that, IT is seen as a platform for improved automation, decision making empowerment, control and coordination, and industry transformation, rather than providing competitive advantage through particular IT applications [38]. The second is keen interest in building fresh organizational structures and processes to assist the innovative and creative use of information technologies [39]. Traditional models of organization based on centralization or decentralization of IT governance are being replaced with a more sophisticated organizing structure that divides particular IT management activities and configures decision rights for particular activities [40]. The last one is that IT industry is still experiencing significant horizontal and vertical fragmentation [41]. As a result, there is an increased level of innovation in IT products, delivery models, and services as IT solutions emerge.

The research business partners found that the business process reference model provides advantages to these three directions above. By its systematic approach it contributes to provide business process models of the same quality for the management platform which aims at improvement in decision making and industry transformation. It helps divides IT management activities, and leads to an innovation in IT products.

The problem faced by the industry partners was that all business process models for the purpose of the management platform should follow the same standard in order to ensure the same quality in terms of gathered information, analysis techniques and information representation of the business process models. One of the approaches towards the reference model was to provide such standardization. Together with the business partners, five key objectives for the reference model (see Table 1.1) were identified. They assist in a systematic development of business process models in design science settings. The reference model itself is in a form of a business process model. Thus, the objectives apply to the model as well as to other business process model artefacts developed with it. The work in this research claims that a business process model artefact should be technology free in the sense that the knowledge about the artefact is not determined by technology in which it might be implemented at later stages. The knowledge base for a process model should come from both academia and best practises. This helps provide the most generic and fully comprehensive set of information for the business model of a domain. In addition it deals with the business types of data as opposed to data instances. Finally, the model must be feasible and applicable to the business and academia projects in design science settings. An ease of understanding will allow more users of the reference model to enjoy full usage and enhances communication between stakeholders.

Table 1.1 Objectives of the Reference Model

The Reference Model
Technology Free
Types of Data
Best Practices & Academia
Feasibility
Ease of Understanding

A construction of the reference model addresses both needs: identification of activities for construction of design science artefacts in design science and systematic research process to build business process model artefacts. The reference model should provide activities referring to the researcher’s skills and decisions making abilities and, at the same time, provide enough insights for those decisions. The users of the reference model should rely on standardized work activities and potentially more creative ones.

Drawing upon the literature and the discussion this research splits the main inquiry with a number of questions to be addressed throughout the thesis. They are illustrated in Table 1.2, which underlines the systematic design and quality focus.

Table 1.2: Research Questions

Reference Model	Business Process Model Artefacts
Q1 How to consolidate different views of the meta-design phase to build the reference model?	Q2 How to systematically approach construction of business process model artefacts?
Q3 How the information quality representation of the reference model can be determined?	Q4 What is the information quality representation of the reference model and its outcomes?
Q5 How to examine theory developed by the reference model in design science settings?	Q6 How the outcomes of the business process model artefacts meet research objectives?

1.5 Thesis Organisation

Chapter Two outlines in detail the research literature review. It presents and discusses design science and its approach to IS research. This is followed by elaboration on design science as theory developer and research methodology. It discusses the construction gap in the meta-design phase, which the reference model is meant to detail in regards to the balance between standardization and creativity in design research.

Chapter Three discusses and defends the selected research methodology. Design science is the chosen research orientation. In presenting the nature of the research, it first introduces the fundamental guideline of design science research. Following on from that, it discusses the research methods in design science research and addresses the ones in this thesis. It examines systematic literature review, focus groups, and interviews in the context of building the artefact, then experimental design, case studies, and self-reports as the design evaluation. As crucial factors in research, validity and reliability are discussed in both building and evaluation the research artefact. It concludes by matching research questions with research methods.

Chapter Four describes the construction and outlines of the reference model artefact. It initially describes the application of design science research with the conceptual framework used to build the model. It then presents a detailed outline of how to undertake the reference model covering activities for business process model development. The activities come from literature review, collaboration with practitioners, and process modelling.

Chapter Five outlines the evaluation of this research work. This is completed by examining utility of the reference model. It employs evaluation perspectives for reference models [24] to evaluate the reference model artefact. An epistemological perspective discusses the model as a scientific theory, which is followed by criteria that are relevant for judging costs and benefits related to the use of a reference model. Then, case studies, which deliberate over the model specifications in a real complex environment, are demonstrated. Finally, the experiments that consider criteria that are relevant for those who work with the model are shown. The information quality dimensions are applied to assess relevance of the reference model to its stakeholders.

Chapter Six summarises the results, underlines limitations, relevance and position of the work. It puts forward the conclusions and future work opportunities that may be of interest to both practitioners and academics. Figure 1.2 illustrates the sequence of the thesis along with the topics associated with each of the chapters.

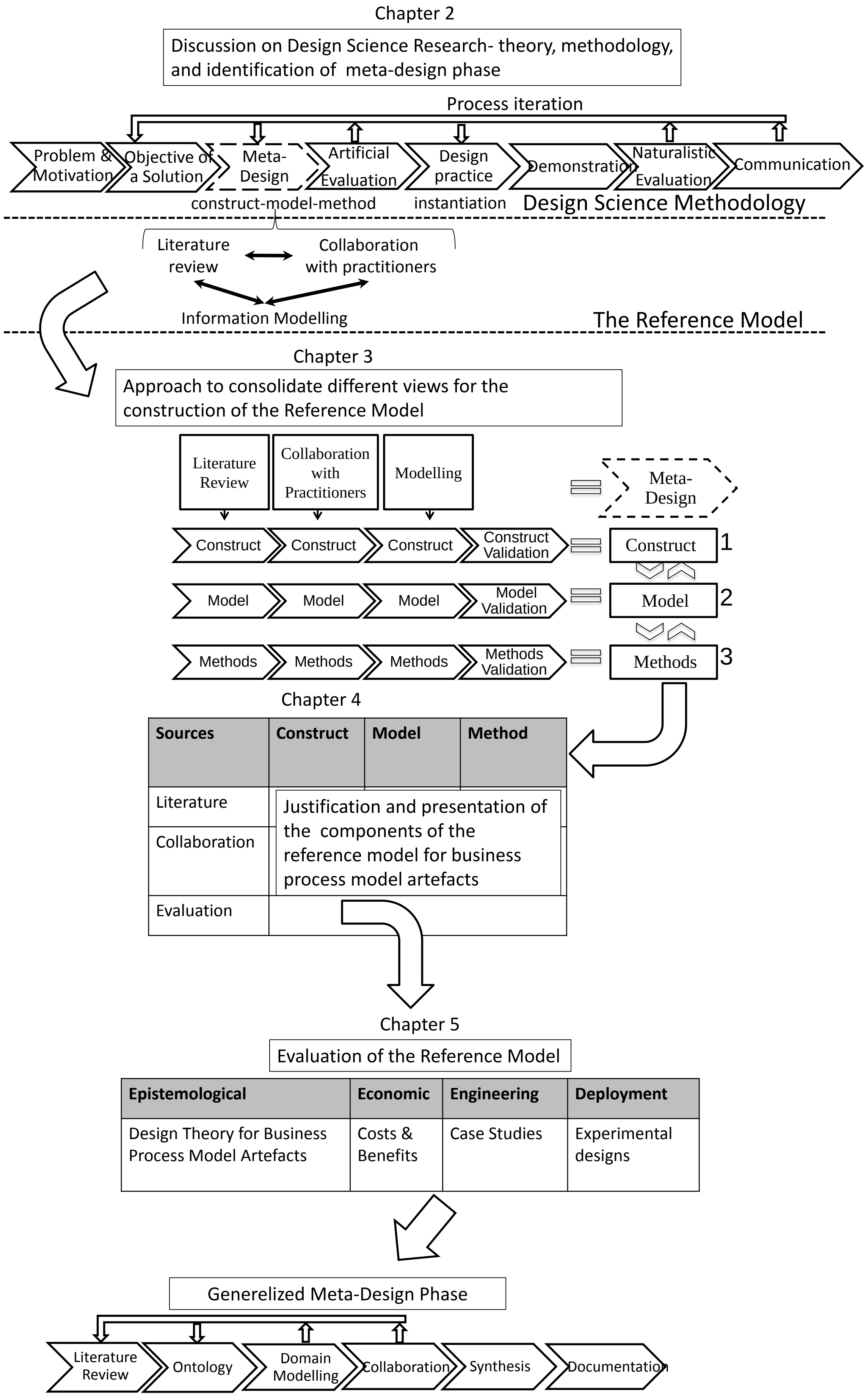

Figure 1.2 : Thesis organisation

2 Literature Review

2.1 Overview

This chapter frames the research within the field of design science and its meta-design phase. This helps to consolidate different views to establish foundations for the reference model. A methodological review of past literature is an essential foundation for any research work [42]. The desire to uncover the hitherto known body of knowledge should not be underestimated [43]. Some fields of study have chronically suffered from lack of proper literature review, which in turn has hindered theoretical and conceptual progress [44]. The value or significance of an effective literature review is to ensure that a researcher demonstrates a full understanding of the body of knowledge related to the studied phenomenon, while at the same time should be explanatory and creative [45]. Moreover, design science paradigm may greatly benefit from an effective methodological literature review in order to strengthen design science as a field of study. In order to conduct academic research in a thorough and professional manner Webster and Watson [42] posit that it is essential that a methodical review of past literature is completed.

Design science research and its methodology have received increased attention in computing and IS research [2,3]. In this chapter, design science research, its methodology, outcomes, and possible evaluation techniques are discussed first. Next, following systematic literature review [46], the main source of conceptions for the reference model is presented to structure the construction gap of the met-design phase in design science. This is followed by discussion of theories that design science research provides. It brings the overview of how to classify theory in information systems, and emphasize their interdependence. This introduces the contribution to design science theory that the reference model provides. In addition, the balance between standardization and the level of creativity, which researchers should be given, is discussed. Then, this chapter examines on information quality which provides criteria to ensure the information representation of the reference model. Finally, it summarizes selection of design science over other research approaches in relation to the objectives of the reference model.

2.2 Design Science Research

Over the last years, design science research has received increased attention in computing and IS research. Generally, research, as a process, "is the application of scientific method to the complex task of discovering answers (solutions) to questions (problems)" [47]. Researchers differentiate between the study of natural systems such as physics, biology, economics and sociology [48], and the creation of artificial ones such as medicine and engineering [48,49].The core mission of the former is to develop valid knowledge to understand the natural or social world, or to describe, explain and possibly predict. The centre of the latter is to develop knowledge that can be used by professionals in the field in question to design solutions to their field problems. Understanding the nature and causes of problems can be a great help in designing solutions. Thus, the focus of design science is on creations of artificial systems. It addresses research through the *building* and *evaluation* of artefacts designed to meet identified business needs [8]. Understanding the nature and causes of these needs can be a great help in designing solutions; however, design science does not limit itself to the understanding, but also aims to develop knowledge on the advantages and disadvantages of alternative solutions [50]. Literature reflects healthy discussion around the balance of rigor and relevance [8] in DS research, which reflects it as a still shaping field [51,52].

2.2.1 Design Science Research Methodology

Several researchers, not only from Information Systems discipline, worked towards guidelines and definition of design science research [8]. Their work in engineering [13,28], computer science [18,19], and IS [18,53,32,54] tried to characterize the purpose of design science, differentiate it from other research paradigms, underline its theory building specifications. They enhanced its essential elements and claimed its legitimacy. This all together provided a collection of appropriate reference literature [23]. Researchers in IS and other disciplines have contributed ideas for design science elements [14,19,13]. However, despite several guidelines, the literature has not explicitly delivered a detailed methodology to carry out design science research [7].

There was a substantial high level of abstraction and lack of specificity for the meta-design phase of the design science methodology.

The main source of conceptions for design science methodology was existing design science (DS) literature. The systematic literature review [46] approach was used, beginning with the most cited papers - e.g. Hevner [8], March [53], gradually reaching towards other relevant publications, and paying particular attention to related special issues and specialist conferences. Closer attention was paid to papers largely methodological, as well as articles that are methodological in part only. Through that process, 22 key articles were identified from which a glossary of DS-related concepts and definitions was compiled.

Those articles revealed four main streams in DS, illustrated in Table 2.1. It can be observed that DS originates from methods in systems development life cycles. Then, the most efforts were put into theoretical and methodological aspects of this paradigm. Later, when DS methodologies started being introduced, it was noticed that some researchers' proposed methodologies for IS artefacts represented combinations of DS and other research paradigms. For example, action design research [55], which combines design and action research. Those instances were classified as variations of design science methodologies.

Table 2.1: Four streams in DS [56]

Systems Development Life Cycle	*Design Science Theory*	*Design Science Methodology*	*Variations of Design Science Methodologies*
Archer [14]	Walls [32]	March [53]	Baskerville [6]
Takeda [19]	Markus [57]	Purao [58]	Carlsson [4]
Nunamaker [47]	Gregor [59,60]	Hevner [8]	Sein [55]
Eekels [13]	Goldkuhl [12]	Cole [20]	
	Pries-Heje [61]	Vaishnavi [23]	
	Venable [22]	Peffers [7]	
		Offerman [34]	
		Alturki [9]	

Figure 2.1 illustrates work, of researchers listed in Table 2.1, towards artefacts of DS methodology over the years. Full circles on Figure 2.1, underlines researchers and their meta-design phases proposed in their methodologies. The empty circles indicate work to which those researchers refereed as influential. Connectors between dots move towards recent years and indicate DS development. In order to make the figure more legible, connections between researchers are narrowed down as in the following example: Markus [57] referred to Walls [32] who picked up on Simon [49], means that

Markus [57] also referred to Simon [49]. In recent years, increasing numbers of DS methodologies are observed.

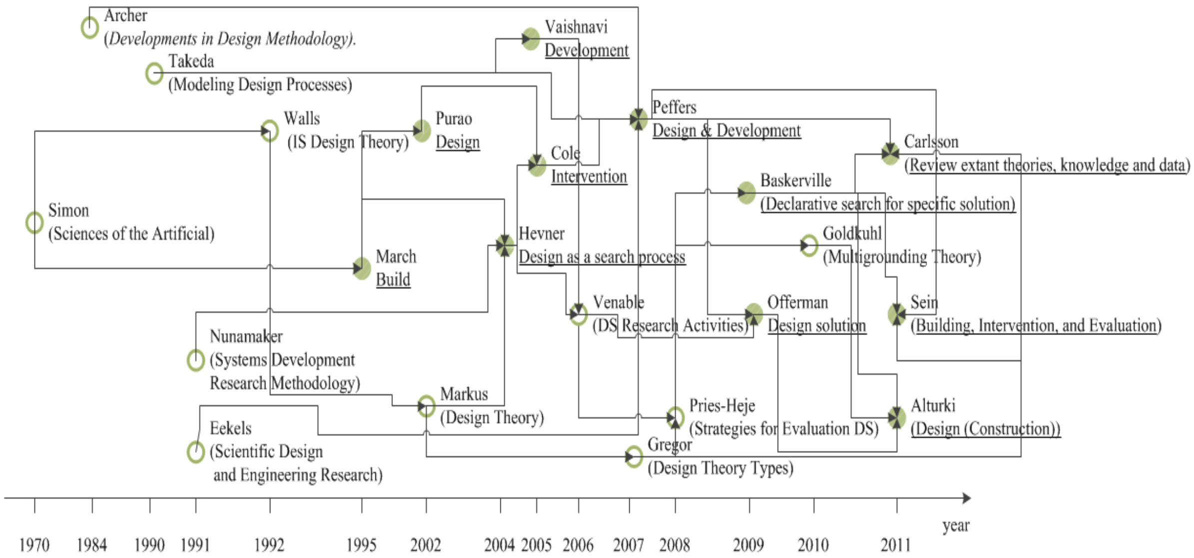

Figure 2.1: Design Science paradigms over years

The Systematic literature review revealed papers that include some components in the initial stages of research to define a research problem. Nunamaker et al. [47] and Walls et al. [32] stressed theoretical bases, whereas engineering researchers [14,13] focused more on applied problems. Takeda et al. [19] suggested the need for problem listing. Rossi and Sein [21] supported the need for problem identification, whereas Hevner et al. [8] asserted that design science research should address important and relevant problems. Based on papers, which stated or suggested process elements, the components of the Design Science Research Methodology (DSRM) were synthesized by Peffers [7]. The result of the synthesis was a high level process model consisting of six activities in a nominal sequence. They are described below and illustrated graphically in Figure 2.2.

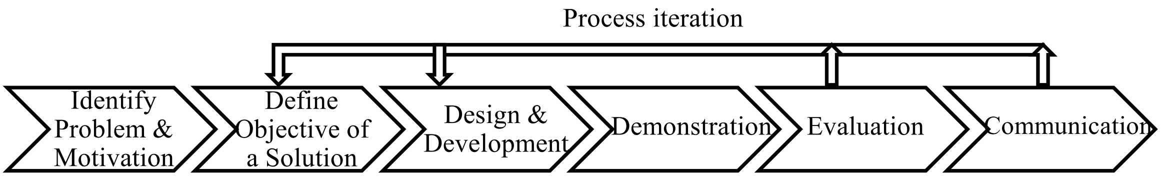

Figure 2.2: DSRM Process Model [7]

Problem identification and motivation defines the specific research problem and justifies the value of a solution. Because the problem definition will be used to develop an artefact that can effectively provide a solution, it may be useful to unify the problem conceptually so that the solution can capture its complexity [7].

Define the objectives of a solution refers to the objectives of a solution from the problem definition and knowledge of what is possible and feasible. The objectives can be quantitative, such as terms in which a desirable artefact would be better than current ones, or qualitative, such as a description of how a new artefact is expected to support solutions to problems not hitherto addressed [7]. In other words the artefact is a mean to provide the solution desired.

Design and Development creates artefacts. Such artefacts are potentially constructs, models, methods, or instantiations [8] or "new properties of technical, social, and/or informational resources" [49]. Conceptually, a design research artefact can be any designed object in which a research contribution is embedded in the design [8].

Demonstration refers to the use of the artefact to solve one or more instances of the problem. This could involve its use in experimentation, simulation, case study, proof, or other appropriate activity. Resources required for the demonstration include effective knowledge of how to use the artefact to solve the problem [7].

Evaluation observes and measures how well the artefact supports a solution to the problem. This activity involves comparing the objectives of a solution to actual observed results from use of the artefact in the demonstration. It requires knowledge of relevant metrics and analysis techniques [7].

Communication refers to the problem and its importance, the artefact, its utility and novelty, the rigor of its design, and its effectiveness to researchers and other relevant audiences such as practicing professionals. This could be in form of a PhD thesis, journal or conference article for academic and in practice communication [34]. In scholarly research publications, researchers might use the structure of this process to structure the paper, just as the nominal structure of an empirical research process (problem definition, literature review, hypothesis development, data collection, analysis, results, discussion, and conclusion) is a common structure for empirical research papers [7].

2.2.2 Outcomes of Design Science

Design science research produces different artefacts at the *Design and Development* phase of DSRM process model [7] (Figure 2.2). The outcome of design science is termed an artefact as discussed in the section 1.1 and can be in form of a construct, model, method, and an instantiation [53,8]. Constructs are demarcated to "concepts", "conceptualizations" [53] or "vocabulary and symbols" [8]. These constructs are abstracted concepts aimed for theorizing and trans-situational use. "Conceptualizations are extremely important in both natural and design science. They define the terms used when describing and thinking about tasks" [53]. Models are not perceived as abstract entities in the same way as constructs. "Models use constructs to represent a real world situation – the design problem and its solution space…" [8] "Models aid problem and solution understanding and frequently represent the connection between problem and solution components enabling exploration of the effects of design decisions and changes in the real world." [8]. A method is termed as "a set of phases (an algorithm or guideline) to perform a task" [53]. Finally, an instantiation represent a prototype or a specific working system or some kind of a tool [12]. Most researchers agreed on those form of artefacts (e.g. [62,9]); however, the methodology to achieve them varies [55,6]. In construction of the artefact two activity phases are observed [62]: 1) design practice that produces situational design knowledge (e.g. a specific instantiation of an artefact) and 2) meta-design that produces abstract design knowledge.

2.2.3 The Meta-Design Phase

The meta-design can be viewed as 1) a preparatory activity to produce the situational knowledge; 2) a continual activity partially integrated with the design practice 3) a concluding theoretical activity summarizing, evaluating and abstracting results directed for target groups outside the studied design and use practices [62]. As a result, four different outcomes for each activity phase are received (see Table 2.2).

Table 2.2: Different outcomes differentiated into abstract vs. situational [62]

Activity phase / Outcome	**From meta-design:** Abstract design knowledge	**From design practice:** Situational design knowledge and results
Constructs	abstract concepts	situational concepts (may be applied and adapted from abstract concepts)
Models	generic models	situational models
Methods	guidelines for design practice	parts of a situational system or process
Instantiation	(systems abstractions with key properties)	Instantiations IT systems (prototype or working system)

Meta-design artefacts are based on data types as opposed to instances of data. Its outcomes are then unreal in some way or ways according to three realities [63], such as unreal users, unreal systems, and especially unreal problems. Thus, meta-design constructs solid and generic background for the design practice activities to construct solutions for a real environment (real people, real artefacts, and real settings [63], it embraces all of the complexities of human practice in real organisations. In other words, the meta-design phase concentrates on providing an optimal solution for the domain by trying to cover the whole spectrum. The design practice refers to it, then, by adjusting and applying it to a concrete business scenario (i.e. an instantiation). Figure 2.3 outlines the extension of the meta-design with two phases and the general relationship among IS artefacts.

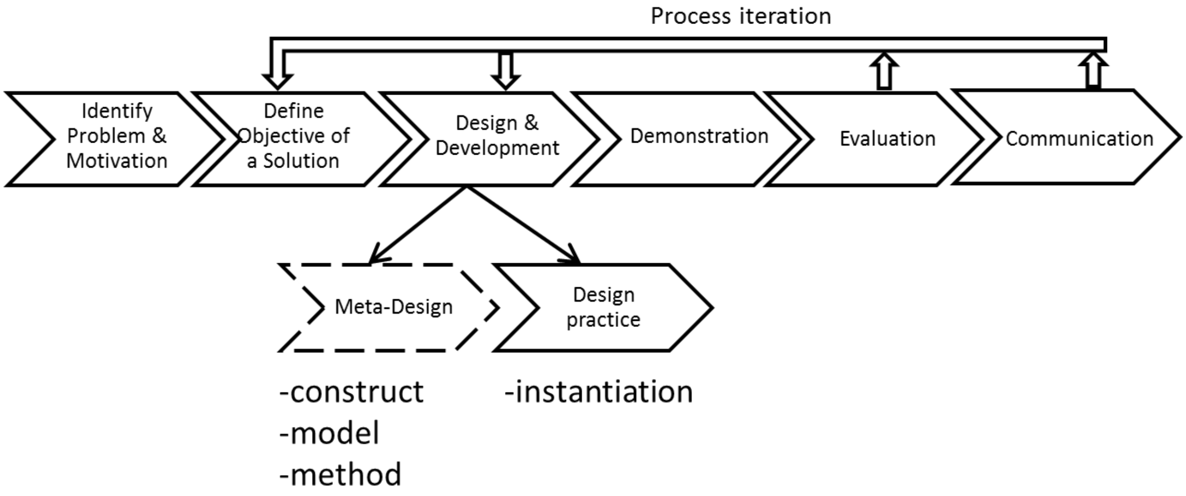

Figure 2.3: Additional layer for DSRM

Meta-design phase plays a crucial role in constructing the blueprint for a final instantiation and utility of design science artefacts [8]. This outlines the challenge to identify activities that are carried out in that phase.

As abovementioned, the meta-design and design practice phase use different types of knowledge (abstract and situational) in regards to the design science outcomes. Thus, it seems reasonable to consider two different evaluation methods – artificial and naturalistic. This enables to determine how outcomes of the meta-design phase should be evaluated. This reflects the environment in which the reference model functions. Hence, the evaluation methods for the meta-design and design practice phases are introduced in the following section. That will conclude the discussion on the approaches to design science research methodology. Then, this chapter will move further into the concerns of detailing the meta-design phase.

2.2.4 Artificial and Naturalistic Evaluation

Evaluation has been a topic both in general IS research and in design science research. In the general IS literature, evaluation is generally regarded from one of two perspectives [64]. In the *ex-ante* perspective, candidate systems or technologies are evaluated before they are chosen and acquired or implemented. In the *ex-post* perspective, a chosen system or technology is evaluated after it is acquired or implemented [64].

Venable [22] classified design science research evaluation approaches into two primary forms: artificial and naturalistic evaluation. Artificial evaluation evaluates an artefact in a non-realistic or manipulated way. Naturalistic evaluation explores the performance of an artefact embedded in solution technology in its real environment (e.g. within the organisation). Naturalistic evaluation methods offer the possibility to evaluate the real artefact in use by real users solving real problems [63], while artificial evaluation methods offer the possibility to control potential confusing variables more carefully and prove or disprove design hypotheses, design theories, and the utility of design artefacts. Having taken into account those two dimensions, Pries-Heje et al. [61] introduced an evaluation framework, which was applied to the DSRM process model and presented it in Figure 2.4. The Design and Development activity was split into meta-design and design practice (see Figure 2.3). Since different artefacts are achieved from each activity, a different evaluation strategy applies.

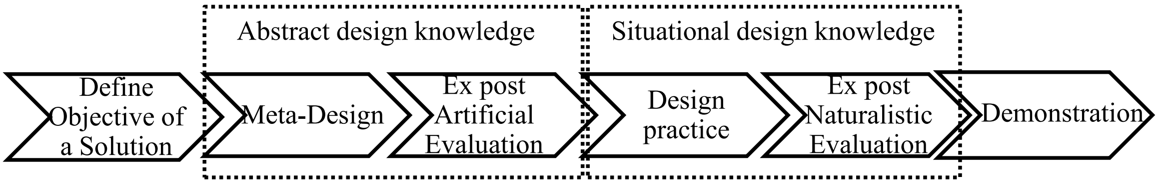

Figure 2.4: A fragment of DSRM [7] with strategic evaluation and different outcomes

Artificial evaluation is selected after the meta-design activity because of its capability to test design hypotheses [32]. Critical techniques may be used, but these generally supplement the main goal of proving or disproving the design theory and/or the utility of the design science artefact. Artificial evaluation includes laboratory experiments, field experiments, simulations, criteria-based analysis, theoretical arguments, and mathematical proofs [61]. Artificial evaluation is then unreal in some way or ways according to the three realities [63], such as unreal users, unreal systems, and especially unreal problems. The naturalistic evaluation fits the purpose of the design practice outcomes due to the capability of performing evaluation in a real environment (real people, real artefacts, and real settings [63], naturalistic evaluation embraces all of the complexities of human practice in real organisations. Naturalistic evaluation methods include field studies, surveys, ethnography, phenomenology, hermeneutic methods, and action research. To the extent that naturalistic evaluation is affected by confusing variables or misinterpretation, evaluation results may not be precise or even truthful about an artefact’s utility or efficacy in real use [61].

The following section focuses on different views of the meta-design phase in design science to determine its structure. This gives the foundation for the construction of the reference model. Then, the philosophical position of design science as a theory developer is discussed. The philosophical position outlines how to approach the design theory provided by design science artefacts, e.g. the reference model.

2.2.5 Foundations for the Reference Model

Different views of the meta-design phase have to be considered in order to determine its fundamental shape which then will constitute the reference model. Thus, the main source of conceptions for the reference model is existing design science literature. It enabled the examination of activities that are undertaken in the meta-design phase of design science methodologies. Hence, these activities may state the core of the reference model which is then further decomposed into detailed tasks or sub-activities. A systematic literature review [46] approach was employed there. It examined common activities that occur across various DS methodologies in a phase in which an actual artefact is being created/produced/developed. Some researchers refer to the phase as build [53], design & development [7], design solution [34] , or develop (construction) [9].

A design science systematic literature review showed that researchers (e.g. [55,23,65]) pointed out to the meta-design phase as the one where the artefact is formed; however, without giving much details on how to approach it. To gain additional details, relevant meta-design phases of their methodologies were connected with case studies that were used in evaluation of their work. Appendix 1 presents findings excluding papers that did not present design science methodologies or put forward case studies that did not provide enough insight to withdraw activities sought. The table in Appendix 1 provides only names of the meta-design phases in proposed design science methodologies and descriptions of undertaken activities in relevant case studies. Commonalities in different phases were out of scope in this search. Upon constructing the table, those activities were analysed in regards to the source from which information about artefact is gathered. Based on the source of information required for the artefacts, two main streams were distinguished. Researchers either reached to relevant literature or collaboration with relevant practitioners in order to obtain information for artefacts. Practitioners are industry experts who regularly do a particular activity in the domain of interest, and are willing to share with their expertise. Table 2.3 shows numbers of case studies where literature and practitioners were involved. A case where researchers referred only to practitioners as the source of information for their artefacts were not found. Numbers of cases in Table 2.3 represent the numbers of case studies in which either practitioners & literature or just literature was used in the meta-design phase. This search indicated, that in 78% of all case studies, the researchers gathered relevant information from literature and practitioners from the field. The rest 22% focused mainly on relevant literature. Practitioners as the only source for constructing artefacts did not occur. Based on the findings, meta-design phase combines knowledge coming from both: best-practises and academia.

Table 2.3: Sources for artefacts

Papers	*Meta-Design Step in DS*	*Literature & Practitioners. No. of cases:*	*Literature No. of cases:*
Offerman [34], Goldkuhl [62]	Design solution	3	1
Peffers [7]	Design and development	3	1
Vaishnavi [23]	Development	1	1
Hevner [8]	Design as a search process	2	0
Carlsson [4]	Review extant theories, knowledge and data	1	0
Alturki [9]	Design (Construction)	2	
Baskerville [6]	Declarative search for specific solution	1	0
Lahrmann [66]	Build	0	1
Sein [55]	Building, Intervention and Evaluation	1	0
Overall	*N/A*	*14*	*4*

Literature review, in the Table 2.3, outlined activities that lead to review the critical points of current knowledge and/or methodological approaches on a particular topic regarding the artefacts investigated. That is considered preparation, gathering knowledge, or building foundation on which the artefact is being constructed. Collaboration with practitioners reveals that the act of designing does not occur in isolation. Focus groups, direct observations, and structured interviews [67] were the most common ways of gathering relevant information. Thus, construction of artefacts is also a process engaging practitioners from the field. The level of engagement may depend on the nature of artefacts.

In the papers analysed, regardless of the preferable sources of information, each artefact was associated with information-modelling activity. This means, there was always a technique to represent the information gathered for further construction of the desired artefact. This is with activities responsible for presenting relevant information in a structured way. Information-modelling became the additional activity for meta-design phase.

These three main activities, collaboration with practitioners, literature review, and information modelling state core activities for the meta-design phase. Because of their capabilities to solve genuine problems as opposed to specific instantiations, this gave reasonable confidence to keep these activities under this phase. These activities stand the core on which the reference model is built. Figure 2.5 illustrates relations and layers between activities identified in the literature review. The figure brings together activities that were spread across and existed in practical usage of design science, but roughly mentioned in descriptions of their methodologies.

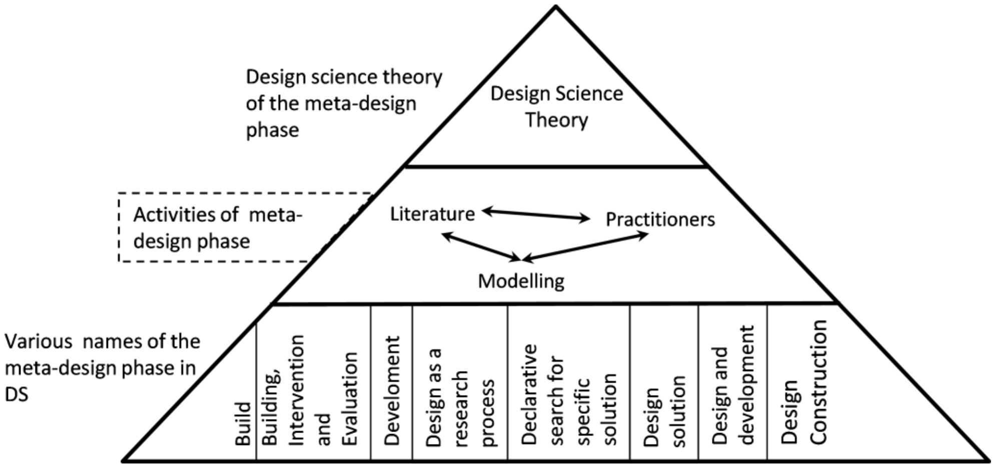

Figure 2.5: Common activities for the meta-design phase in DS [68]

The meta-design phase contains double arrows between the literature and collaboration. It indicates that information gathered from one source is confronted with the other. In the sense, how a theory from literature is actually used in practice, and how the best practice reflects the theory. As doing so, the information gathered is double checked and its relevance to the artefact becomes more solid, in the sense of validity and relevancy. In terms of information-modelling techniques, it can be distinguished between modelling the knowledge as it is gathered and modelling the knowledge into the structure of the domain sought (see Figure 2.6). The former is achieved by applying techniques that give researchers the design rationale of a knowledge base, kernel conceptualization of the world of interest, and semantic constraints of concepts. The latter applies the knowledge base to the specific domain modelling techniques.

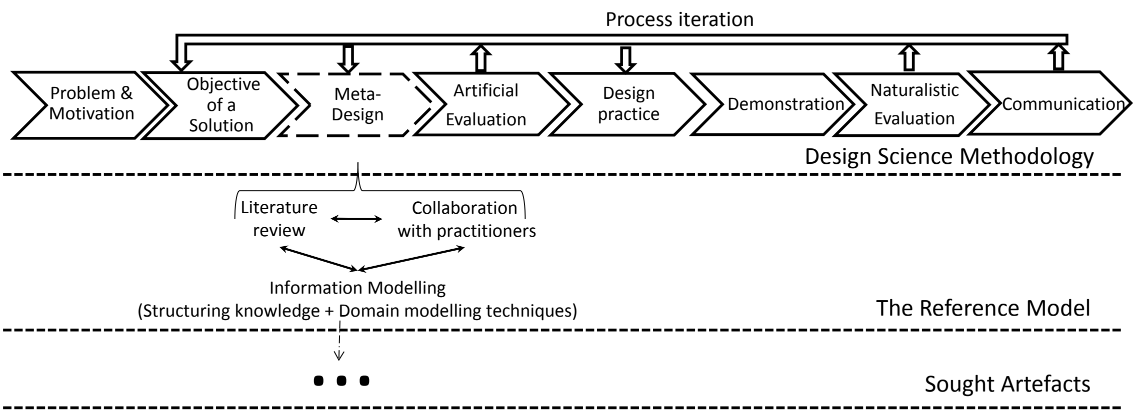

Figure 2.6: The Meta-Design phase in the Design Science Methodology [68]

Figure 2.6 illustrates a high level of this design science research methodology. Further decomposition of the meta-design phase as the reference model is in chapter 4.

The following section presents the philosophical position of design science as a theory developer. By developing a new artefact researchers, provide important contribution to theory. The following section underlines what type of theory design science artefacts provide in IS field and how the contribution of the reference model can be approached.

2.3 Design Science - Theory Contribution

This section discusses how to classify theories developed with design science and how the theory developed by the reference model can be examined and perceived. Despite the recognition of the need for theory development in design science [23,56], there is discussion in IS forums of what theory means in IS and what form contributions to knowledge can take [60]. The word theory is used rather broadly to embrace what might be called elsewhere frameworks or body of knowledge. Dictionary definitions [69] outlines that the word theory can be of many meanings, including "conception or mental scheme of something to be done, or the method of doing it; a systematic statement of rules or principles to be followed," a "system of ideas or statements held as an explanation or account of a group of facts or phenomena; a hypothesis that has been confirmed or established by an experiment, or accepted as the known facts; statements of what are held to be the general laws, principles, or causes of something known or observed," a "mere hypothesis, speculation, conjecture"

Design science researchers outlines that theory contains certain types of entities that exist independently of human beings and human knowledge of them [60]. At a high level this view corresponds to ideas expressed by both Habermas, and Popper [70,71]. The former recognizes three different worlds - the objective world of actual and possible states of affairs, the subjective world of personal beliefs and experiences gained, and the social world of regulated social relations. These three worlds are related to Popper's Worlds 1, 2, and 3 [71]. World 1 is the objective world of material things; World 2 is the subjective world of mental states; and World 3 is an objectively existing but abstract world of man-made entities - language, art, mathematics, institutions, and ethics. Thus, theory as an abstract entity belongs to World 3. In this research the concern is with theory as World 3 entity, existing outside an individual mind. To conclude, a design theory is something in an abstract world of man-made things, which includes other abstract ideas such as algorithms and models [60] .

Gregor [59] pointed out to the importance in examining the nature of design theory in IS separately from other disciplines. For example, theory in physic and psychology means different things and knowledge is developed, specified, and used in different ways. Thus, the nature of theory in IS could differ from that found in other disciplinary areas. A characteristic that distinguishes IS from other fields is that it concerns the use of artefacts in human-machine systems [60]. IS theory links the natural world, the social world, and the artificial world of human's constructions. Hence, the body of knowledge that is needed draws on natural science, social science and what has been termed design science [8,49]. The attributes of such a body of knowledge are elaborated on in the following sub-sections. Developing theory is what sets academic researchers apart from practitioners and consultants, there is nothing is as practical as a good theory [72]. Theories enable knowledge to be accumulated in a systematic manner and this accumulated knowledge enlightens professional practice.

2.3.1 Theory Classification in Information Systems

A classification theory for IS proposed by Gregor [60] begins with the primary goal of the theory. This is a research problem that is to be solved or some question of interest. The theory that is developed should depend on the nature of this problem and the questions that are addressed. The word goal here means the goal of the artefact in the sense that it is the *causa finalis*, the final cause or end of the artefact (following Aristotle's writing on the four explanations of any "thing" in The Four Causes, [73]). Gregor [60] pointed out that the goal of a theory is "what the theory is for": analysing, explaining, predicting, or prescribing. Following the primary goal line of thought four fundamental goals of theory are distinguished and described as follows [60]:

- *Analysis and description.* The theory provides a description of the phenomena of interest and analysis of relationships among constructs and the boundaries within which relationships, and observations hold.
- *Explanation.* The theory provides an explanation of how, why, and when things happened, relying on varying views of causality and methods for argumentation.
- *Prediction.* The theory states what will happen in the future if certain preconditions hold. The degree of certainty in the prediction is expected to be only approximate or probabilistic in IS.
- *Prescription.* A special case of prediction exists where the theory provides a description of the method or structure or both for the construction of an artefact. It

takes the form: "If you want to achieve Y in situation Z, then something like action X will help" [48].

Combinations of fundamental goals lead to the five types of theory shown in the left-hand column of Table 2.4. The classification system proposed by Gregor [60] resulted from an iterative process involving the study of the nature of theories occurred in IS, examination of work to date, and analytic classification of the classes of theory. Some further distinctions among theories in the literature do not depend on the structural nature of the theory. Some theory types emerge from the association with particular epistemological positions or with particular socio-political aims [74].

Table 2.4: A Taxonomy of Theory Types in IS Research, based on [60]

Type	Distinguishing Attributes	Contribution to knowledge
I. Analysis	**Says what is.** It does not extend beyond analysis and description. No causal relationships among phenomena are specified and no predictions are made.	Theory that describes and analyses is valuable, when **little is known about some phenomena**. Descriptions presented should correspond as far as possible to "what is" [75]
II. Explanation	**Says what is, how, why, when, and where**. It provides explanations but does not aim to predict with any precision. How and why things happened in some particular real-world situation.	The theory developed, or the conjectures, need to be new and interesting, or to explain something that **was poorly or imperfectly understood beforehand**.
III. Prediction	**Says what is and what will be**. It provides predictions and has testable propositions but does not have well-developed justificatory causal explanations. The focus of the theoretical model is on prediction, because that is the theorist's primary interest.	The discovery of regularities that allow prediction can be of interest if these were unknown before; especially if the **theory's predictive power is of considerable practical importance**.
IV. Explanation and Prediction	**Says what is, how, why, when, where, and what will be**. It has contributions from both *process* studies, which look at the unfolding of events over time, and *variance* studies, which look at the degree to which one variable can predict changes in another variable [76].	Studies can usefully contribute **to either theory building or theory testing.** Many authors provide discussion of how "scientific" knowledge should be generated and tested (for example, Cook and Campbell [77]; Popper [78])
V. Design and action	**Says how to do something**. The theory gives explicit prescriptions (e.g., methods, techniques, principles of form and function) for constructing an artefact.	Theory for design and action **does not imply that one course of action is better than another** in a moral or ethical sense. Models and methods can be evaluated for ease of use and the quality of results obtained through use of the method [8].

These types III and IV on the Table 2.4 outline the common concept of scientific-type theory in the natural sciences model. The type V – design and action theory outlines that a theory can be a principle of form and function, methods, and justificatory theoretical knowledge that is used in the development of IS artefacts [32,79].

However, these three theories are strongly interrelated [60]. Knowledge of people and information technology capabilities guides design science researchers through the design and development of new information system artefacts. These artefacts can then be applied to the theory types of III and IV. Design science literature provides an example from the history of science of the interaction between scientific knowledge and technologies. The invention of the telescope allowed Galileo to make astronomical observations and confirm predictions made from theory about the phases of Venus [80]. Construction of the telescope relied on knowledge of optics for its design theory and principles.

There are many views on the status of design theory and its relationship to other types of theory. The relevant work is scattered and appears under different names in various publications: a software engineering research [81], as a constructive type of research [82], as prototyping [83], as a systems development approach [84,47], and as design science [8,49]. Figure 2.7 depict the necessary philosophical ideas on which IS discipline theories rely.

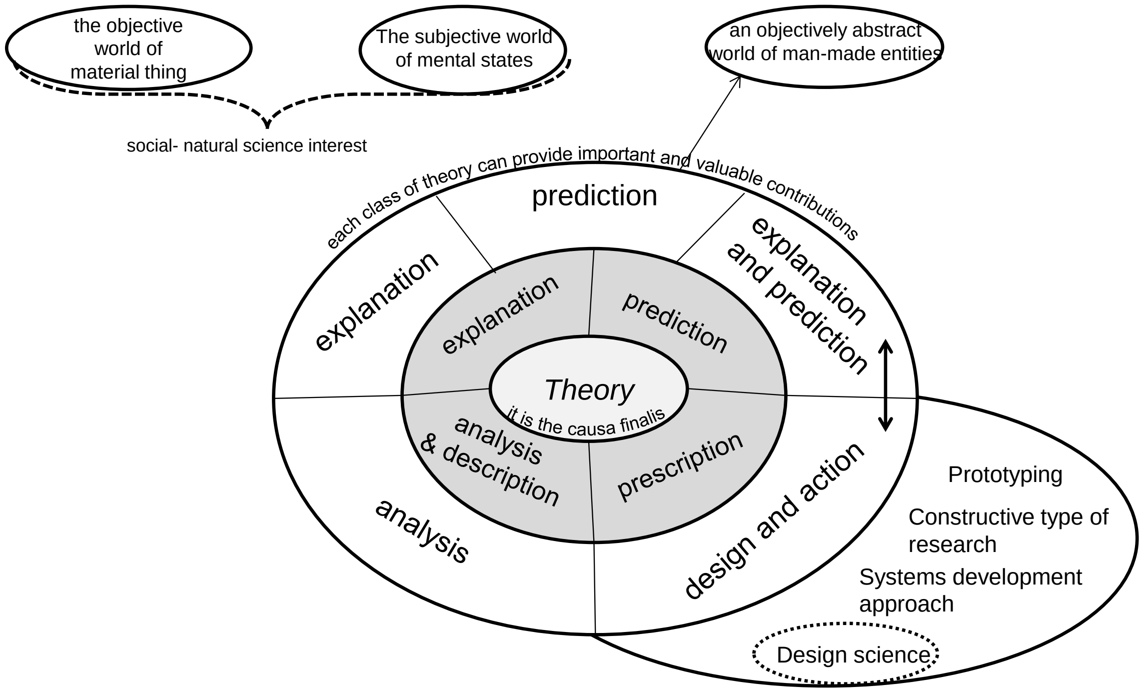

Figure 2.7: A philosophical position of design science adapted from [60].

A design theory is something in an abstract world of man-made things, which includes other abstract ideas such as algorithms and models. A design theory instantiated would have a physical existence in the real world, e.g. a reference model

Researchers [53,8] see four design artefacts produced by design science research: “constructs, models, methods and instantiations” as discussed in the section 2.2.2 However, their tend to see “theory” as the preserve of the natural sciences; although, on occasion, they use the word “theory” for the knowledge produced by design science. Following Dubin [85] and Nagel [86] “constructs, models and methods” can be one type of thing and can be equated to theory or components of theory, while instantiations are a different type of thing altogether as shown the section 2.2.2.

Following the taxonomy in Table 2.4, Gregor distinguishes components of theory types in IS research [60]. These are shown in Table 2.5. The seven components of justificatory provide an explanation of why the design works. The goal of explanation is common to many current conceptualizations of theory [86,78].

Table 2.5: Seven components of an Information Systems Design Theory, based on [60]

Components	Description
Theory Component (Components Common to All Theory)	
Means of representation	The theory must be represented physically in some way: in words, mathematical terms, symbolic logic, diagrams, tables or graphically
Constructs	These refer to the phenomena of interest in the theory.
Statements of relationship	These show relationships among the constructs. The nature of the relationship specified depends on the purpose of the theory. Very simple relationships can be specified: for example, “x is a member of class A.”
Scope	The scope is specified by the degree of generality of the statements of relationships and boundaries showing the limits of generalizations.
Theory Component (Components Contingent on Theory Purpose)	
Causal explanations	The theory gives statements of relationships among phenomena that show causal reasoning.
Testable propositions	Statements of relationships between constructs are stated in such a form that they can be tested empirically.
Prescriptive statements	Statements in the theory specify how people can accomplish something in practice (e.g., construct an artefact or develop a strategy).

These components from Table 2.5 are sufficient to provide an idea for an artefact to construct [59]. The instantiation of the artefact does not always have to be present. Some particular innovative ideas may have merit, despite the lack of an instantiation. The history of computing shows that some conceptual work on design, without instantiations or implementation principles, has been influential. For example, the device called Memex, described in the 1930s by Vannevar Bush [87], and his subsequent essay, "As I May Think," in 1945 has had a pivotal influence in hypertext research. However, Bush did not provide a working model for his ideas or a method for building a Memex.

Components listed in Table 2.5 allow IS researchers (1) to identify what theory is composed of in general and (2) to analyse the components of their own theory and the theory of others. This specification can be used for description and evaluation of a design theory emerging from a design science artefact.

The following sections discuss to which extent standardization of the reference model in design science methodology will not negatively interfere with researcher’s flexibility and creativity. This is to determine the balance between standardization and creativity in the context of expected level of details for the meta-design phase in design science.

2.4 Creativity and Standardization

Design science underlines the significance of a rigorous and relevance approach in IS research [8]. Research institutions supervise how work is performed and encourage researchers to standardize work practices and to adhere to consistent sets of procedures that have been found to be successful [88]. On the other hand, researchers are given certain level of creativity in investigation of the research domain and formulate their research problems. Creativity has been described as the cornerstone of change, the foundation of innovation, and a key to effectiveness [89,90]. Consequently, researchers are faced with an interesting choice of standardized work practices or creativity that enhances their overall effectiveness. In traditional work designs, supervisor decides what work practices are most applicable for assignments, and a researcher carries them out accordingly. However, in more complex research work configurations, researchers are responsible for deciding how work is to be conducted and how best to achieve overall effectiveness [91,92]. Thus, these types of research work are discussed to determine the expected level of standardisation and creativity in the reference model settled in design science methodology. It concerns the research stakeholders' satisfaction and researchers' performances.

2.4.1 Creativity in Research

Creativity in research can be described as a mean to ensure that research remains flexible and is able to successfully adjust to new artefact being investigated. The use of creative processes has long been proffered as an important driver of effectiveness [93,94], as well as having been theorized to significantly increase performance [89,90], such associations have been empirically examined [95]. A creative work process covers activities and behaviours that are directed at developing novel solutions for various tasks [96]. It can be viewed as a means of identifying problems, using guesswork, communicating ideas to others, and contradicting what would normally be expected [97]. Creating a research environment or framework that encourages creativity is a necessary condition for the occurrence of creative outcomes [96]. A *creative environment* is one in which researcher is encouraged to engage in creative activities and to employ creative work processes. Researchers are exposed to a broad range of perspectives, skills, and information that they can use to generate ideas and form new and different options for the design science artefact [98,99]. Creative research environment should encourage researcher to try new things, which may results in more creative artefacts. Artefacts that explore alternative ways to accomplish their goals should be able to meet the needs of their stakeholders. In other words, researchers' attitudes and motivation translate into behaviours that result in positive stakeholder experiences. Although most creativity research has focused on creative outcomes, much of this work has been premised on the idea that there is a positive association between creativity and motivation (e.g. [89]).

2.4.2 Standardization in Research

Standardized research practices detail how activities should be performed; their goal is to reduce the variance associated with each task and, thereby, improve overall effectiveness [100]. A vital component of standardization is the use of an approach to analyse work processes, so that problems can be highlighted, new information applied, mistakes can be learned from, and consistent quality of artefacts achieved [101]. Therefore, following standardized work procedures derived from systematic research methods should enhance research performance [102].

Many methods designers try to follow the approach of standardized work practices to provide researchers with techniques, mechanisms, or guidelines for how activities are to be performed [103]. Research standardization helps ensure that high-quality artefact is delivered to stakeholders [104].

Much of the influential work on quality argues that standardization positively influences stakeholders' expectations e.g. [101]. Standardized work practices result in stakeholders perceiving that researchers are knowledgeable and possess a clear set of tools to appropriately develop the artefact.

2.4.3 Combined Effects of Creativity and Standardization

Although both creativity and standardization have been linked to the research performance and stakeholder's satisfaction, their underlying mechanisms vary. Creativity stresses taking risks and trying new and different solutions, whereas standardization embraces the development of work patterns that are consistently applied. Consequently, the core of the creativity paradigm is *enhancing variation* to optimize the fit between researchers' efforts and outcomes, whereas the core of standardization is *minimizing variance* to ensure consistent operations [95].

Researchers should be well positioned to acquire the potential benefits of both creativity and standardization. Such researchers are usually highly trained on the tasks they perform, as well as on how to handle a complex research domain [91]. For instance, during planning sessions, researchers decide how to allocate tasks, how work will be sequenced, and so forth. During research they make decisions on such matters as which material to include, how to diagnose problems, which experts may provide the best insights to the work. Each of these options involves trade-offs with regards to expenditure, time, and current, as well as possible future, research performance and stakeholders' satisfaction. Although these conditions appear to be mutually exclusive, both standardization and creativity must be considered for successful long-term planning [105]. Researchers argued that routines can result in flexibility and change [88]. In addition, researchers indicate that creativity may be most valuable when combined with high levels of standardization. However, low level of standardization with high levels of creativity may result in chaos and not be at all beneficial.Researchers found that documented procedures have higher levels of stakeholder's satisfaction. However, researchers with more creative environments have significantly higher levels of performance, with work standardization not being a significant predictor [95]. These results suggest that design science stakeholders may prefer standardization as it removes ambiguity from their service interactions. However, with highly skilled and well-trained researchers, a creative environment rather than work standardization appears to benefit performance. Thus, a design science research should focus mainly on standardization that will positively moderate the influence of creative work. The creative activities are to be explicit when occurring with high standardization whereas muted when occurring in combination with low standardization.

In addition, researchers may need to be skilled in using both approaches—creativity and standardization—and should learn to adapt their work styles as circumstances warrant [95]. Researchers may or may not need to engage and disengage in certain activities and behaviours as a situation occurs [106]. A potential limitation of this discussion is the measure of creativity. In the presented literature, researchers used measures of the extent to which a research environment encouraged or fostered creativity. It was pointed out that evaluation of such research process benefits from case studies and qualitative techniques, such as observation of researches at customer sites and in research meetings. Another strategy is to utilize some type of "experience sampling method" [107], in which researchers are asked to report what they are doing.

In conclusion, this section underlined the importance of creative research environments for research effectiveness. The quality movement [102] stresses the importance of process improvement and continual learning. Design science researchers should be encouraged to be creative in tandem with using standardized work practices in order to maximize both performance and stakeholder satisfaction in design science. This above-mentioned relationship is to be employed in the reference model artefact.

The following section discusses information quality which provides criteria to ensure the information representation of the reference model. Then, it is followed by the summary of the selection of design science over other research approaches in relation to the objectives of the reference model (Table 1.1).

2.5 Quality of Design Science Artefacts

Quality cannot be taken for granted or assumed. Instead, quality is a “subjective term for which each person has his own definition. In technical usage, quality can have two meanings: 1. The characteristics of a product or service that bear on its ability to satisfy stated or implied needs, and 2. A product or service free of deficiencies.” The notations to satisfy and to be free of deficiencies confirm the potential subjectivity of quality [108].

|If methodology is regarded as a human activity system, it then can be applied by the same sort of quality dimensions as applied to any other systems, including information systems themselves [33]. From these quality dimensions, the principles of methodology design can be perceived in terms of the quality characteristics expected of a good methodology. The objectives of the reference model call for a good information representation quality. Hence the information quality is examined to determine information representation dimensions for the reference model.

In addition, design science artefacts are perceived through their utility by the solution seekers [8]. Thus, the utility of artefacts is a subjective matter. According to users’ expectations, users evaluate the extent to which information products (e.g. the artefacts) are fit for the intended use. Since subjective standards and expectations vary from person to person, each user will generate an individual opinion [109]. To integrate and standardise these opinions a particular attention was paid to the information quality that interacts with the end users and might measure the fitness for use. [110].

2.5.1 Information Quality

Information quality research can be broadly classified into two research communities: database and management. The database community follows a technical and data schema oriented approach. Most research arising from this community defines information quality on the basis of data values or instances of data models that are consistent to specifications in data schema, e.g. [111]. Research related to the management community is business and management focused. Approaches proposed from this community follow the concepts and principles of total quality management in the way that researchers regard information quality in the light of information that is fit for use by information consumers, e.g. [110]. If the methodology is only applied to one information quality community, it is considered as specific methodology. If the methodology can be applied to both information quality communities, it is a generic methodology. Due to the two research communities, information quality assessments are differentiated into objective and subjective assessment [112]. This classification was followed to discuss information quality assessment from both objective and subjective perspectives.

Objective information quality assessment is used to measure the extent to which information conforms to quality specifications and references. The objective information quality assessment subdivides into two categories: intrinsic and real-world information quality assessment. Intrinsic information quality assessment accords with the data perspective and focuses on the quality of the data in the database. Real-world assessment follows an ontological perspective and focuses on information quality deficiencies that can take place during the system design and data production [113]. Wand and Wang [113] identified data mapping deficiencies between the real world state and information system representation. Overall, objective information quality assessment can be considered as the procedure of comparing current data value with an ideal data value.

Subjective information quality assessment is used to measure the extent to which information is fit for use by information consumers. Information consumers assess information quality according to their demands and expectations. Subjective information quality assessment follows the user perspective and focuses on any discrepancy between the current quality of information and the user’s expectation. Table 2.6 indicates the differences between objective and subjective information quality assessments.

Table 2.6 Comparison of objective and subjective information quality assessment [109]

Methods / Feature	**Objective Assessment**	**Subjective Assessment**
Tool	Software	Survey
Measuring Object	Data	Information Products
Criteria	Rules, Patterns	Fitness for use
Process	Automated	User Involved
Assessing Result	Single	Multiple
Data Storage	Databases	Business Contexts

Objective information quality assessment uses software to automatically measure the data in a database by a set of quality rules, whereas subjective information quality assessment employs surveys or an interview approach to measure contextual information by data consumers. A single assessment result can be obtained from objective assessment. However, it is more than probable that different information consumers will generate different assessment results. Subjective assessment methodology [114] measures the fitness for use of artefact by conducting surveys, and interviews with information consumers (e.g. information seekers) [112].

Different kinds of classification have been proposed to organize information quality dimensions. The widely accepted hierarchical framework proposed by Wand and Strong [110] consists of four categories: intrinsic, information quality, contextual, representational. The representational category falls within the scope of the objectives of reference model, which concerns whether the information is presented in an easily interpretable way. Other researchers proposed classification by three main factors that influence information quality: the perception of the user, the information itself, and the process of accessing information [114]. Bovee [115] proposed information quality categories as a sequence of four phases: obtaining the information, understanding the information, connecting the information with the given context, and assuring the information does not contain any errors.

Although the term of representational information category matched with this research scope, its dimensions were further examined due to the inconsistency between different approaches to information quality dimensions. Systematic literature review outlined 6 most influential studies in information quality. Table 2.7 presents information quality dimensions falling within the definition of the representational information category among other information quality dimensions.

Table 2.7 Dimensions for representational information category

Authors / Dimensions	Wand [110]	Eppler [116]	Bovee [115]	Lee [117]	Holmes [118]	Pipino [112]	∑
Accessibility		X	X				2
Accuracy		X				X	2
Interpretability	X	X	X	X	X	X	6
Easy of understanding	X	X	X	X	X	X	6
Reliability					X		1
Consistency	X	X		X	X	X	5
Relevancy			X	X			2
Concise	X		X	X	X	X	5
Believability				X			1

Following the frequency that is greater than half of the total literature collected; four significant dimensions for representational information quality were selected. These were: interpretability, easy of understanding, consistency, and concise. They represent the fitness for use of the information provided to stakeholders. In the line with critical measurement validation [119], measuring items for each dimensions were determined and validated [109]. Table 2.8 illustrates measuring items for each dimension.

Table 2.8 Represetationl information quality dimensions and measuring items [109]

IQ Dimensions	Attributes of Items		
Interpretability	Interpretable	Without inappropriate language and symbols	Readable
Ease of understanding	Easy to understand	Easy to comprehend	Easy to identify the key point
Consistency	Consistent meaning	Consistent structure	Presented in the same format
Concise representation	Concise	Compact	

Information quality dimensions in Table 2.8 along with their measuring items serve to measure quality of information represented by either the methodology or its outcomes. The score of their measure indicates how well the information is represented to the end user and if it fits its purpose. In other words, it shows the utility of the information to the user of that information. These representational information quality dimensions can be used to evaluate the subjective character of information provided by design science artefact.

The following section outlines that further structuring of the meta-design phase with regard to the objectives of the reference model (see Table 1.1) can be achieved by framing the reference model on the design science approach. This constitutes that the research problem comes from design science and the solution expected is also achieved by applying this paradigm. By this research structure, additional activities to the reference model are introduced as examined by following design science methodology.

2.6 Approaches to the Reference Model

Having considered the objectives of the reference model (section 1.4) and its methodological character; this section examines existing research approaches and justifies selection of design science. To ensure rigor and relevance for this research process, approaches mostly used and cited in the IS field [120,8,121] are compared in conjunctions with practitioners from the field. The design science methodology selected is further described in chapter 3. The focus of this section is to consider and justify the selection of design science approach as the most suitable base on which the objectives of the reference model can be achieved.

As discussed in the chapter 1, the general approach for the reference model was to use one of available research approaches as the core of the reference model and then adjust it accordingly to the needs of the business process model artefacts. Systematic literature review and research participatory indicated plausible research approaches that offer systematic techniques or modes of inquiry in the creation of a satisfactory outcome in the line with the objectives of the reference model. Upon application of the objectives to the approaches, design science research emerged as the one that may lead to meet the objectives of the research process. The sub-sections delineate their conceptions in the light of the objectives (see Table 2.9).

Table 2.9: Research approaches

	Objectives of the Reference Model				
Approach	*Technology free*	*Types of data*	*Best practice & academia*	*Feasibility*	*Ease of understanding*
Software Engineering Research	○	●	◍	●	◍
Action Research	○	◍	◍	●	●
Design Science Research	●	●	◍	●	◍
Ontology Engineering	●	●	◍	○	◍
Method Engineering	◍	◍	○	◍	○

Match with Objectives

○ weak ◍ moderate ● strong

2.6.1 Software Engineering Research

It is a systematic, disciplined, quantifiable approach to the development, operation, and maintenance of software, and the study of these approaches [122]. It is the application of engineering to software because it integrates significant mathematics, computer science and practices whose origins are in engineering [123].

Despite great advances in software engineering research, requirements capture remains the most difficult and least formalized development phase [124]. To understand what software is to be constructed, it has to be put into the context of the business processes that it is supposed to support. This support can range from storage and retrieval of business data to decision support or even to full automation. In all cases, an understanding of the underlying business processes is required. Researchers and practitioners in management information systems (MIS) have long recognized that understanding the business processes, that an information system is supposed to support, is a key to eliciting the needs of its users. However, they lacked the conceptual tools to represent such processes and to relate descriptions of such processes to the requirements of the information systems that support them. Proponents of object-oriented modelling have argued that object models enable to model the “real world” [125] in a way that all stakeholders can understand. However, a number of experts agree that object models lacked the vocabulary to express business processes in a natural and intuitive way [126,127].

Requirements capture is arguably the most important phase in software engineering, and yet the most difficult and the least formalized one [124]. Enterprises build information systems to support their business processes. Software engineering research has typically focused on the development process, starting with user requirements—if that—with business modelling often confused with software system modelling [125]. Researchers and practitioners in management information systems have long recognized that understanding the business processes that an information system must support is key to eliciting the needs of its users (see e.g., [128]), but lacked the tools to model such business processes or to relate such models to software requirements. Researchers and practitioners in business administration have long been interested in modelling the processes of organizations for the purposes of understanding, analysing, and improving such processes [129], but their models were often too coarse to be of use to software engineers. The advent of ecommerce and workflow management systems, among other things, has led to a convergence of interests and tools, within the broad IT community, for modelling and enabling business processes.

In conclusion, the software engineering research is mostly oriented on building solutions in the limitations of dedicated technology. It struggles with a formalized approach to capture information from practitioners and academia. Some solutions of software engineers are not fully comprehended by the end users. Table 2.9 represents how this approach reflects the objectives of the reference model.

2.6.2 Action Research

This approach has been extensively discussed in the IS literature [130,131]. A widely adopted definition of action research (AR) by Rapoport [132] characterizes it as follows: “Action research aims to contribute both to the practical concerns of people in an immediate problematic situation and to the goals of social science by joint collaboration within a mutually acceptable ethical framework". According to this definition AR has a dual goal of contributing to practice and research at the same time. The definition assumes that there is a concrete client involved. As a consequence, AR is highly context dependent while attempting to address the specific client's concerns. This corresponds with inductive Action Research approach [121] in which "theory is generated from the data (…) of thick descriptions of the patterns of subjective meanings that organizational actors use to make sense of their worlds, rather than entailing the testing of hypotheses deduced from a priori theory that causally explains what has been observed by the action researchers". Thus, much of AR is conducted to understand existing reality, such as the complex workings of organisational situations and human behaviour. Although an action researcher may search for regularities and causal relationships in the social world or may apply such when interpreting the world, AR clearly recognizes the limits of such regularities. Each AR project is unique and the case can only be understood from the point of view of the individuals who are directly involved in the activities which are to be studied. As a consequence, in accordance to [133], AR was interpreted as a research method clearly idiographic.

In conclusion, action research interest does not necessarily construct new and innovative ways to solve a class or classes of problems, thus creating new reality. It focuses on solving a socio-technical problem by developing and a new solution technology and evaluating it in an organizational context. Table 2.9 represents how this approach reflects the objectives of the reference model.

2.6.3 Ontology Engineering

There are many interpretations about what ontology is. In fact, the ontology community has come to an agreement on giving up its definition [134]. The ontology in this research falls within the definition by Gruber [135]. Ontologies are agreements about shared conceptualizations. Shared conceptualizations include conceptual frameworks for modelling domain knowledge; content-specific protocols for communication among inter-operating agents; and agreements about the representation of particular domain theories. In the knowledge sharing context, ontologies are specified in the form of definitions of representational vocabulary.

Ontological Engineering is a research methodology which gives researchers the design rationale of a knowledge base, kernel conceptualization of the world of interest, semantic constraints of concepts together with sophisticated theories and technologies enabling accumulation of knowledge which is dispensable for knowledge processing in the real world. Ontology engineering characterizes the computational architecture of a knowledge-based system which performs domain ontology which characterizes knowledge of the domain [136], a problem solving process like diagnosis, monitoring, scheduling, and design. The idea is to serve as a system of the vocabulary/concepts used as building blocks for knowledge-based systems which might provide researchers with an effective methodology and vocabulary for both analysing and synthesizing knowledge-based systems. However, it does not cover the control structure but do components or primitives of unit inferences taking place during performing research [137].

In conclusion, the ontology engineering provides a common vocabulary of an area and defines, with different levels of formality, the meaning of the terms and the relationships between them. However, the relationships itself does not offer sequential view necessary to underline the data flow in business artefacts. For the business process model artefacts, data flow is crucial. Nevertheless, the ontology engineering delivers techniques that can be used in gathering and shaping knowledge for a desired business process. Therefore, some aspects of this technique are adjusted and embedded in the reference model for knowledge representation purpose. This is outlined in section 4.4.1. Table 2.9 represents how this approach reflects the objectives of the reference model.

2.6.4 Method Engineering

Method engineering in the field of information systems is the discipline to construct new methods from existing methods [138]. It focuses on the design, construction and evaluation of methods, techniques and support tools for information systems development [139]. From the engineering perspective, a method is made up of a set of product models and a set of corresponding process models. A product model represents the concepts that are used in the method, relationships between these concepts as well as constraints that they have to satisfy. A process model represents the way to accomplish the development of the corresponding product [140].

There are two facets in a method engineering process. One is re-engineering of existing methodologies into smaller methods or method chunks and describes the methodology as a set of configured modules. These method chunks are stored in a method chunks repository. The second is to assembly of situation-specific methods based on existing method chunks [140]. A method chunk is an autonomous and coherent part of a method supporting the realisation of some specific system development or management activity. Such a modular view of methods favours their adaptation, configuration and extension. Moreover, this view permits to reuse chunks of a given method in the construction of new ones. Still however, there exist no authoritative compilations of method chunks that can be assembled to fit particular project contexts, and such that deliverables of applying one method chunk, can be mapped to inputs of another method chunk. Method chunks are rarely presented as elements that are separated from the problems solved with them, or from the cases used to illustrate their application. There is no agreed taxonomy of method chunks. Methods are in the heads of people, and not yet in the services of systems. There are no services to assess which methods to use in a given situation, given the bounded rationality of the engineer, often, sub-optimal methods are selected, making projects expensive and crippling system development.

In conclusion, method engineering offers solutions as a conjunction of available methods. However, these methods are hardly separable from their original scenarios and therefore rarely applicable for other problems. As a research process, it does not take into account the impact from engaging various experts that may provide valuable insights to the sought method. It is not applicable to the needs of the reference model because it has to apply to business world which changes rapidly and flexibility in the research is advised. Table 2.9 represents how this approach reflects the objectives of the reference model.

2.6.5 Design Science Research

There is no widely accepted definition of design science research (DSR). Some Researchers characterize design research as “yet another lens" or set of analytical techniques and perspectives for performing research in IS [23]. Design research involves the analysis of the use and performance of designed artefacts to understand, explain and very frequently to improve on the behaviour of aspects of IS. The design science paradigm seeks to extend the boundaries of human and organizational capabilities by creating new and innovative artefacts, including constructs, models, methods, and instantiations [53,8]. Other authors identified “solution technology invention” as the core of DSR [141]. Design science following van Aken [50] belongs to the scientific study of artificial systems (as opposed to the natural one) to develop knowledge that can be used by professionals in the field in question to design solutions to their field problems. Thus, design science as a research activity invents or builds new, innovative artefacts for solving problems or achieving improvements, i.e. DSR creates new means for achieving some general (un-situated) goal, as its major research contributions. Such new and innovative artefacts create new reality, rather than explaining existing reality or helping to make sense of it [51]. The artefact to be developed is assumed to have some purpose [8,59]. Utility maximization is considered as the ultimate goal of DSR and that, overall, they privilege managers as a stakeholder group on business organizations. Design science approach is elaborated in section 2.2

In conclusion, design science had the strongest score in relation to the objectives of the reference model as an approach that aims engaged academia and practitioners in development of new knowledge. The engagement must result in a solution that is applicable and at the same time can be applied to different scenarios. In addition DSR may be perceived through the category problem: action research, ontology engineering, method engineering, and software engineering research are research methods while DSR is more a research orientation, within which one can use different research methods (e.g. the listed above). Table 2.9 represents how this approach reflects the objectives of the reference model.

Next section summarizes the literature above and underlines the links between the reference model in design science, its outcomes, design theory provided, and representational information quality.

2.7 Research Themes

The literature review above revealed the potential research questions concerning insufficient details in design science methodology, design science theory types, and core activities that state the reference model. It discussed how detailed should be the reference model in order to guarantee research efficiency and flexibility. Finally information quality were examined which helps to assess how well the reference model represents information to its users. This section highlights the research themes to bridge gaps in design science methodology, and outline the research agenda

Design Science research methodology has been applied to various IS projects. Following an overview of some available and relevant design science literature, a common problem was identified in this methodology. Researchers struggle with the phase when the design science artefact is being constructed. As discussed in section 2.2, design science methodology does not provide too much detail about this phase due to the fact of enormous variety of possible IS projects and expected artefacts. However, the analysis in this research showed some common activities that can be applied across most of IS projects following design science methodology. Although at the general level their application is reasonable, their operational level requires specification of IS projects.

As discussed in the chapter 1, this research aims to bring the operational level to the meta-design phase of design science methodology.. To keep the research challenges more structured and transparent, this research work is shaped along a number of research themes, which help in formulation of specific research questions. These challenges were split into three categories, Construction, Quality, and Impact. This classification enables to employ the most appropriate research methods in a consistent manner. Figure 2.8 illustrates these themes which are further discussed upon below.

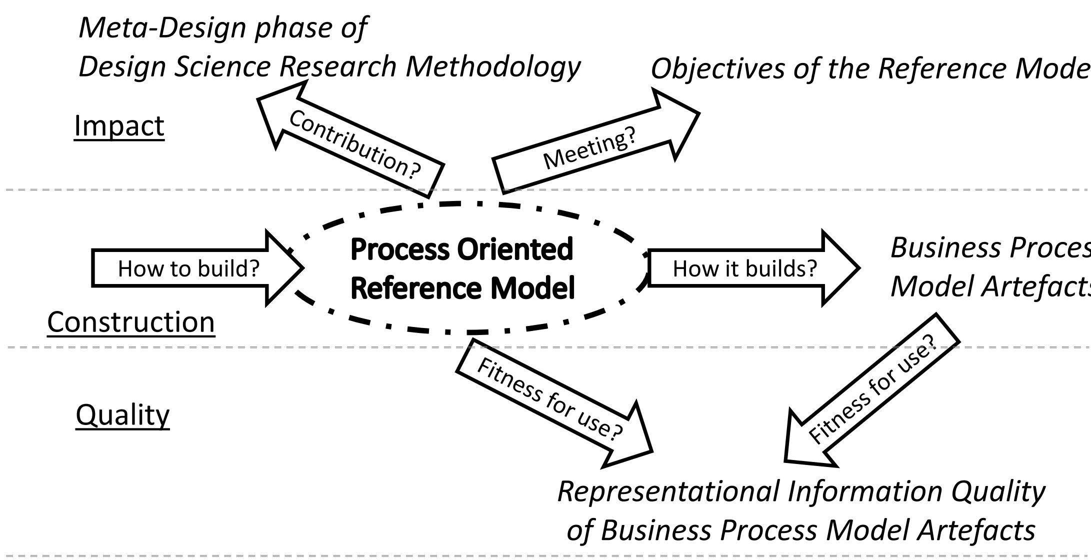

Figure 2.8 Concerns of the Reference Model

2.7.1 Research Theme - Construction

The scope of this theme is to answer two research questions regarding construction artefacts in design science. The lack of specificity of the meta-design phase in design science can be discovered by answering the two following questions:

1. *How to consolidate different views of the meta-design phase to build the reference model?*
2. *How to systematically approach construction of business process model artefacts?*

The first question tried to narrow down to the operational level of core activities identified in section 2.2 for the meta-design phase in design science methodology. The operational activities serve to guide design science researchers in constructing business process model artefacts in design science settings. They constitute the reference model in form of a business process model artefact. As this was the first research work to investigate the activities for constructing the design science artefact-the reference model, It had to follow the general design science research methodology, and select suitable activities as learning by doing. Hence, the selected activities used to build the model became already the part of the model. In other words, this research work had to follow some activities to build the process model, thus if some activities which turned out to be of value in construction of business process model, they were added to the reference model. This way, all activities in the model are already validated, because their usefulness was shown during the research.

Once the reference model is built, the second question on how to carry on design science research with the goal of business process model artefacts is addressed. This enables identification of general activities to construct other types of artefacts.

2.7.2 Research Theme - Quality

The scope of this theme was to answer two research questions regarding the quality of information representation by the reference model and its outcomes. Quality of design science artefacts are perceived through their stakeholders. In this research, the most attention was paid to the researchers using the reference model and stakeholders of the business process model artefacts. The content of the business process models highly depends on the skills and motivation of individual researchers whereas the way the content is represented at varies stages of the research relied in the interest of the reference model. Hence, these two following questions concern the representational information quality of process oriented design science artefacts.

1. *How the information quality representation of the reference model can be determined?*
2. *What is the information quality representation of the reference model and its outcomes?*

The first question concerned the information represented to the user by the reference model. It was measured the extent to which information was fit for use by information consumers. Information consumers used representational information quality dimensions to assess information quality of artefacts according to their demands and expectations [113]. A similar approach was taken towards the stakeholders of the business model artefacts constructed with the reference model. The focus was on how the reference model helps communicate between researcher and the stakeholders.

2.7.3 Research Theme – Impact

The scope of this theme was to demonstrate what impact has the reference model on the design science research methodology, design theory that emerges from it, and research objectives. The section 2.3 discussed that design science artefact provides theory to its relevant discipline. Each theory type can provide important and valuable contribution. The section 2.2 discussed that impact of the design science artefact on the business requirements is measured by matching how well the artefact matches the business objectives. The following questions try to find answers to these challenges:

1. *How to examine theory developed by the reference model in design science settings?*
2. *How the outcomes of the business process model artefacts meet research objectives?*

First question examined components of the reference model to define the theory it provides. The model is analysed from various perspectives such as utility to a community of users, the novelty of the artefact, and the persuasiveness of claims that it is effective. In addition, development of the reference model was followed by the design science methodology and by meeting business requirements from the question two; the utility of this approach could be demonstrated. Hence, the answer to question two had two implications. First it examined how well the research objectives are met, and if these were substantial, it proved the legitimacy of the model. It is worth noticing that the reference model is a business process model artefact of the design science methodology. Therefore, it can be used to address the question two.

2.8 Summary

The main focus of this research is to define and validate activities for meta-design phase of design science methodology by constructing the reference model. The reference model guides researchers in development of business process model artefacts in design science settings. Based on the literature review, several conclusions can be drawn.

- Design science is a promising methodology in Information Systems discipline. Its relevance and rigours has been observed in recent years. However, as an emerging methodology, it still requires some work around its systematic execution. This thesis aims to detail activities involved in building design science artefacts with the scope of process oriented artefacts.
- A design science artefact is a theory in an abstract world of man-made things, which includes other abstract ideas such as algorithms and models. For example,

the reference model. In other words the knowledge produced by design science is a design theory with its prescriptive characteristics. This thesis aims to shape the theory developed with the reference model

- A comprehensive guideline for design science researchers at the operational research level is needed in the field. Three main activities were identified in the literature review. These were: systematic literature review, collaboration with practitioners, and modelling. Their general character is narrowed down for the purpose of business process model artefacts. Chapter 4 provides such detailed activities with accompanied characteristics.
- The literature indicated the importance of keeping the right balance between standardization and creativity in research. The balance is applied by providing activities that let researchers get relevant skills to do research on the process, and then support researcher with activities that allow usage of these skills creatively.

The following chapter will outline and justify the principles of design science methodology. It elaborates on the individual methods selected to each part of this research, which is split into build and evaluate parts. The build part covers systematic literature review, design science conceptual framework, focus groups, and interviews. The evaluation part discusses experimental designs, design theory, and case studies. The research themes outlined in this chapter are matched with the abovementioned methods in order to indicate how the research questions are addressed.

3 Research Methodology

3.1 Introduction

When research is undertaken to find answers to questions, it has been understood that it is conducted within a framework of a set of approaches, procedures, or methods that have been tested for their validity and reliability, and are designed to be unbiased [142,143]. Creswell [144] defines research as "a process of phases used to collect and analyse information to increase the understanding of a topic or issue". It follows three phases: pose a question, collect data to answer the question, and present an answer to the question. Another definition by Grinnell [145] defines research as the “careful, systematic, patient study and investigation in some field of knowledge taken to establish facts or principles”. Research expects that valid and reliable methods have been used to address research questions. Validity means that correct procedures have been applied to find answers to a question. Reliability refers to the quality of a measurement procedure that provides repeatability and accuracy.

This research follows design science methodology by approaching it as a research orientation, within which one can use different research methods [51]. A mixture of qualitative and quantitative methods is addressed. These are executed following the high level process of design science research proposed by Peffers [7] as outlined in the section 2.2.1. The relevance and rigour of these methods are ensured by embedding them in design science research framework [8] and applying design science guidelines [8]. At the operational level a research design is introduced to outline the methods used. Relevant research quality tests are applied to each method to ensure their reliability and validity. These abovementioned are elaborated and illustrated in the following sections.

3.2 Research Orientation

In information system research, research methodologies are split into qualitative and quantitative research. The former approach has the goal to understand social or human problems from multiple perspectives in natural settings. It involves a process of building a complex and holistic picture of the phenomenon of interest. The latter identifies a research problem based on testing a theory, measured with numbers, and analysed using statistical techniques. Its goal is to determine whether the predictive generalizations of a theory hold true [146]. Both quantitative and qualitative methods have their advantages. To address problems in this research, a mixture of them was found most suitable. The mixture is desirable and feasible due to the fact that it gives a more complete view. Requirements during different phases of the research project make very specific demands on a methodology. While it is demanding, it is more effective to choose the right method for the problem at hand. Hence, in Chapter 4 qualitative methods are used such as systematic literature review, focus groups, and interviews to build the reference model. In Chapter 5, it is used experimental design accompanied with questionnaires to validate the model. These methods involve scientific data analysis and therefore are classified as quantitative research. Case studies are used to observe and record behaviour of the reference model in its natural settings.

Information systems research contributes to the understanding of a phenomenon. In the case of design research, all or part of the phenomenon may be created as opposed to naturally occurring. [23]. The phenomenon is then a set of behaviours of some entities that is found interesting by the researcher community. Western research communities desire the knowledge that allows prediction of the behaviour of some aspect of the phenomenon. Vaishnavi [23] pointed out that the set of activities a research community considers appropriate to the production of knowledge are its research methods or techniques (e.g. the reference model). This specific phenomenon of interest in design science differs from some other research communities that have nearly universal agreement on the phenomenon of interest and the research methods for investigating it.

The chapter 2 discussed an extensive review of design science and its application in IS research; with a view offering general guideline on its application. This methodology was presented for the construction and presentation of design science research in IS. Figure 3.1 illustrates possible entry points in the design science process. In this research, a reference model artefact was proposed that guides design science researchers in construction of business process models. Following the model in Figure 3.1, this research process was entered at the *Identify Problem and Motivation phase* outlined in chapters 1 and 2.

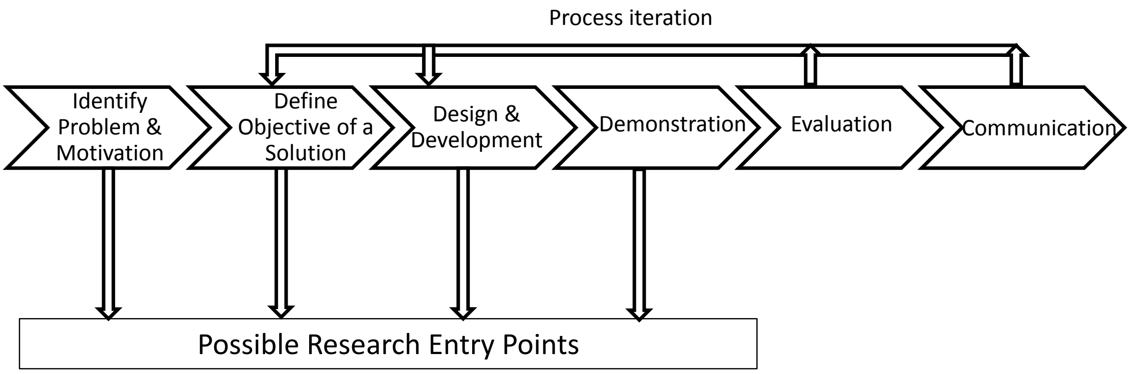

Figure 3.1 Entry points for design science research. [7]

Hevner et al. [8] present a conceptual framework as illustrated in Figure 3.2 and a set of practice rules for IS research combining behavioural science and design science paradigms. The balancing research cycle offered by this framework combines interactions between systems, people and technology. This framework not only enables to position this work but also helps identify the appropriate methods to address the research questions.

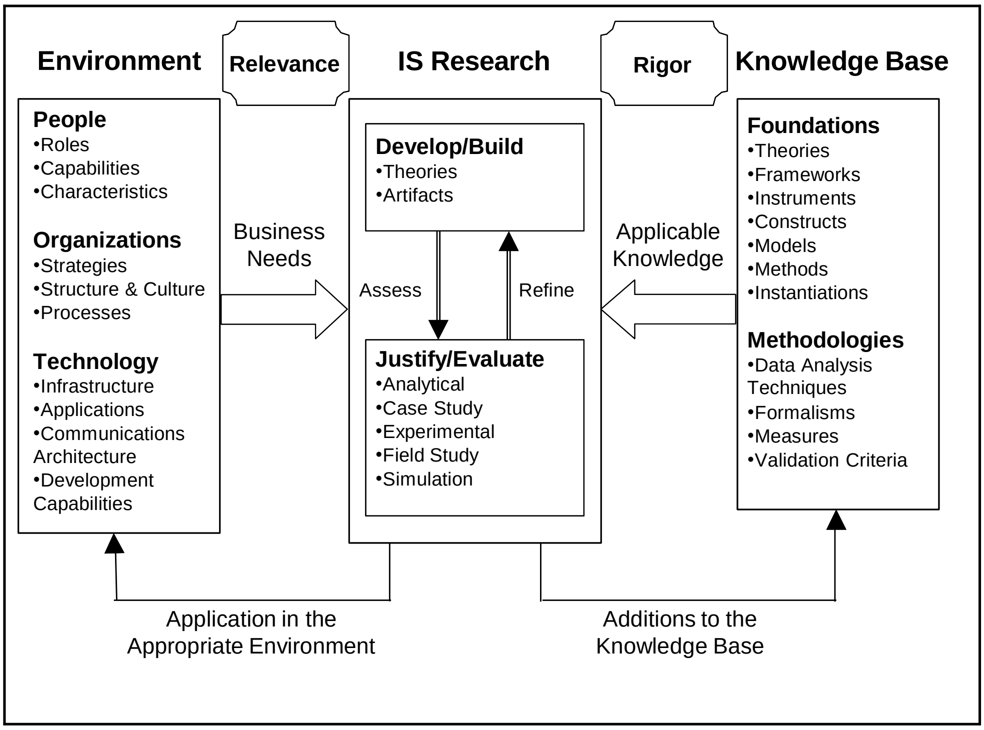

Figure 3.2 Information Systems Research Framework [8]

The relationship between business needs and applicable knowledge states the basis for the application of the framework. Research methods at the Justify / Evaluate phase aim to identify potential weaknesses in the theory developed along with a need to refine and reassess. The Develop / Build phase is to which the applicable knowledge of the framework provides the base for which IS artefact is achieved. This includes models and methods that are the basis for foundational theories. Rigor is assured by applying existing foundations such as theories and frameworks along with data analysis and validation criteria. Simon [49] pointed out that a design theory in IS research is a necessity as it must be aligned to business needs and requirements and existing bodies of knowledge. Design theories such as in-memory databases, mobile computers, voice over IP have positive effect on how IS are perceived by many. Therefore researchers further suggest that the manner in which IS researchers conduct their research in these environments must be adaptive and process-oriented [8]. Accordingly these principles were applied to this research and endeavoured to conform to the best practice.

In the following sections, Hevner's research framework [8] is applied for the construction and evaluation of the reference model artefact. Selections of qualitative and quantitative research methods that go along with the framework to address the research themes are illustrated. Then, it is elaborated in-depths on the selected methods grouping them into Build and Evaluate phases. Finally, each research theme and their questions are outlined along with the appropriate methods.

3.3 Methods Selection

Section 2.2 underlined suitability of design science approach to address the research problem posed by this research. There has been a significant and on-going theoretical discussion in the IS field as to the nature and compatibility of design science (DS). Some researchers claim that DS is similar to action research, if not identical [51]. Fundamentally, any method being equated to DS suffers from a category problem. For example, action research is a research method while DS is more. It is a research orientation within which one can use different research methods (e.g. action research). DS is means-end-oriented. The artefact developed is assumed to have some purpose [59]. Moreover, some researchers consider utility maximization as the ultimate goal of DS, so that favour managers as a stakeholders group. However, DS may more easily have a critical orientation. DS may aim at developing new artefacts that challenge existing power structures of domination. The Scandinavian trade-unionist IS development approach, is an example of this orientation [82].

Researchers identified a number of methods that can be used for evaluation of design science artefacts. Hevner [8] proposed five classes of evaluation methods: (1) Observational methods may include case study, questionnaire, and field study. (2)

Analytical methods include static analysis, architecture analysis, optimization, and dynamic analysis. (3) Experimental methods include experimental design, simulation. (4) Testing methods include functional testing and structural testing. (5) Descriptive methods include informed argument, and scenarios. As discussed in the section 2.2, the activities identified state the core to build design science artefacts. These were systematic literature review, information modelling, and collaboration with practitioners which may comprise for example interviews or focus groups.

Table 3.1 lists prevalent methods in Information Systems [147], and marks these methods determined by design science literature review (section 2.2) as suitable for design science research, and used for the purpose of this work. In this research, none of these methods is superior to all others. Each has strengths and weaknesses, which can be of value if used appropriately. Following Kaplan et al. [147], different research methods were combined to improve the quality of this research work.

Table 3.1 Research methods for Design Science research

Case Study	X	Simulation	
Field Study		Functional Testing	
Static Analysis		Structural Testing	
Architecture Analysis		Informed Argument	
Optimization Analysis		Scenario	
Dynamic Analysis		Interview	X
Experimental Design	X	Focus Groups	X
Questionnaire	X	Systematic Literature Review	X

In order to strengthen this research, 6 research methods were used in this thesis: case study, experimental design, questionnaire, interview, focus group, systematic literature review. This research design requires selection of the most appropriate methods to address the research themes as identified in Section 2.6. Figure 3.3 illustrates the methods selected with the relationships between the environment and knowledge base inherent to this research framework. A number of seminal frameworks have been widely applied in many situations [9].

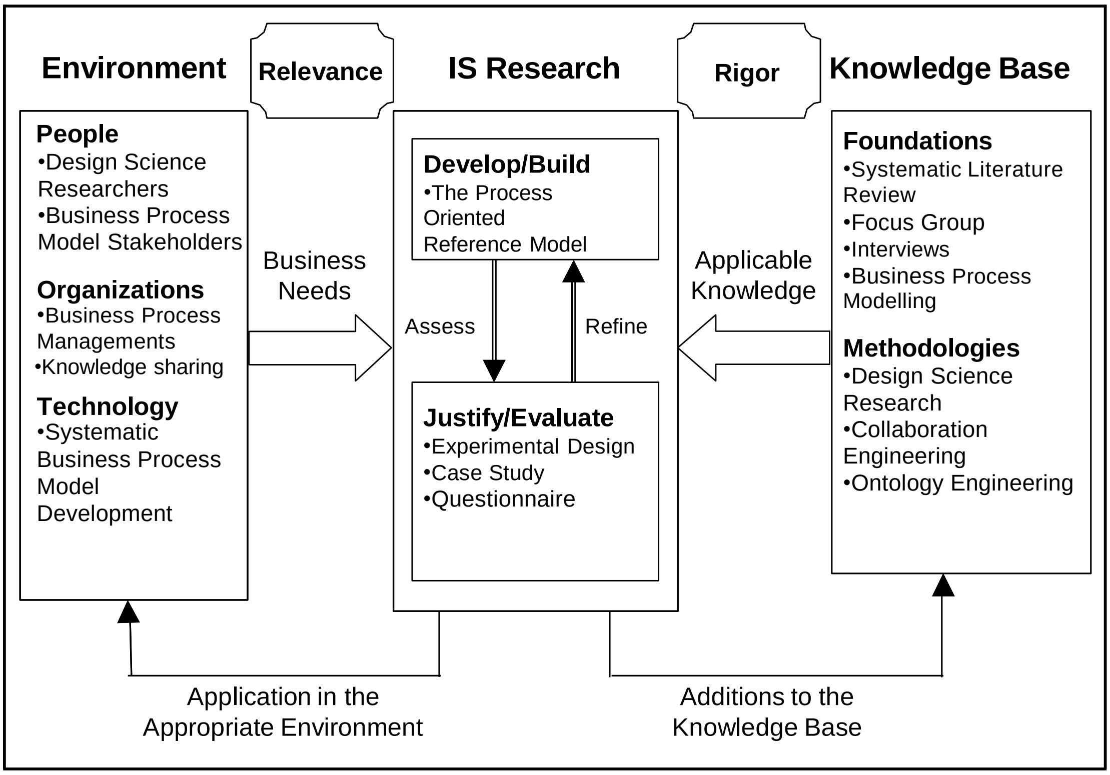

Figure 3.3 Design Science Research Framework for the Reference Model Artefact

To ensure that the reference model artefact has been built in a scientific way, systematic literature review, focus groups, and interviews were used. These methods are introduced in this chapter 3, whereas chapter 4 presents their execution. The Business Process Model and Notation 2.0 (BPMN) was applied to shape the reference model as the business process model artefacts. This research examined activities for business process models artefacts in order to determine general activities for construction of design science artefacts. The research themes and individual questions imposed an obligation to employ a multiple of methods. In order to address the questions identified in the three themes (section 2.7), the design science methodology (see Figure 3.1). This means that the questions are answered sequentially as the requirement to build the reference model and then evaluate it. The iterative nature of the application of the framework (Figure 3.3) and the ability of the researcher to adopt improvements are considered critical for the successful exploration of research questions proposed [8]. Before each research method is discussed in detail in the section 3.5, seven design science research guidelines are outlined that adhere to the principle that knowledge, understanding and solution are achieved in building and evaluating design science artefacts [8] with the focus on the reference model artefact.

3.4 Design Science Research Guidelines

As discussed in sections 2.3 and 2.2 design science is essentially a problem solving process. The assumption on which the following principles are based on is that knowledge and understanding of a design science research problem and its solution are acquired in the building and application of an artefact [8]. Hence, design-science research focuses on the creation of an innovative, purposeful artefact (Guideline 1) for a specific problem of a domain (Guideline 2). The purpose of the artefact is seen through its utility which can be achieved thanks to thorough evaluation (Guideline 3). The innovative aspects can be proved by solving hitherto unsolved or known problem in a more effective or efficient manner (Guideline 4). The artefact itself must be rigorously defined, formally represented, coherent, and internally consistent (Guideline 5). The ultimate goal of the process of design is to discover a solution to a research problem in an iterative manner (Guideline 6). Finally, the output of the design-science research must be communicated to both a technical audience (researchers who will extend them and practitioners who will implement them) and to a managerial audience (researchers who will study them in context and practitioners who will decide if they should be implemented within their organizations) (Guideline 7) [8]. These seven guidelines assist researchers to understand the requirements for effective design-science research. However, each of these guidelines should be addressed in some manner for design-science research to be complete. How well the research satisfies the intent of each of the guidelines is then a matter for the reviewers, editors, and readers to determine. Table 3.2 summarizes the seven guidelines. Each is discussed in detail below and linked to design science research on the reference model artefact.

Table 3.2 Design Science Research Guidelines Summary [8]

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. Design foundations, and/or design methodologies.
Guideline 2: **Problem Relevance**	The objective of design-science research is to develop technology-based solutions to important and relevant business problems.
Guideline 3: **Design Evaluation**	The utility, quality, and efficacy of a design artefact must be rigorously demonstrated via well-executed evaluation methods.
Guideline 4: **Research Contributions**	Effective design-science research must provide clear and verifiable contributions in the areas of the design artefact.
Guideline 5: **Research Rigor**	Design-science research relies upon the application of rigorous methods in both the construction and evaluation of the design artefact.
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.
Guideline 7: **Communication of Research**	Design-science research must be presented effectively both to technology-oriented as well as management-oriented audiences

3.4.1 Guideline 1: Design as an Artefact

The outcome of design-science research in Information Systems (IS) is a purposeful artefact created to address an important organizational problem. Following Weber [148] theories of long-lived artefacts must explain how artefacts are created and adapted to their changing environments and underlying technologies. Hevner et al. [8] recognized that artefacts are not only the instantiation but also constructs, models, methods applied in the development and use of information systems. Artefacts are perceived not as independent of people or the organizational and social contexts in which they are used but as interdependent and coequal with them in meeting business needs. The forms of artefacts such as constructs, models, methods, and instantiations are equally crucial and that design-science research efforts are necessary for their creation. They are innovations that define the ideas, practices, technical capabilities, and products through which the analysis, design, implementation, and use of information systems can be effectively and efficiently accomplished [149,150]

3.4.2 Guideline 2: Problem Relevance

Acquisition of knowledge and understanding are the main objectives of IS. These enable the development and implementation of technology-based solutions to hitherto unsolved and important business problems. Design science approaches these objectives through the construction of innovative artefacts aimed at changing the phenomena that occur. Each must inform and challenge the other. Design science researchers are challenged to create artefacts that enable organizations to overcome the acceptance problems predicted. Combination of technology-based artefacts (e.g. interfaces, in-memory databases), organization based artefacts (e.g. reporting relationships, social media reporting), and people-based artefacts (e.g., training system) are necessary to address such issues [8]. The relevance of any design science research effort is with respect to a relevant community. In design science research such a community are "stakeholders who plan, manage, design, implement, operate, and evaluate information systems and those who plan, manage, design, implement, operate, and evaluate the technologies that enable their development and implementation." [8] This community welcomes effective artefacts that enable this type of problems to be addressed: constructs by which to approach them, models by which to visualize and explore, methods by which to analyse or implement them, and instantiations that demonstrate how to affect them.

3.4.3 Guideline 3: Design Evaluation

Evaluation methods in design science must be rigorously demonstrated to show the utility and quality of artefacts. Evaluation plays a crucial role in design science research. The research objectives derived from business establishes the requirements upon which the evaluation of the artefact is based. Evaluation environment would be the technical infrastructure which itself is incrementally built by the implementation of new artefacts. Hence, evaluation includes the integration of the artefact within the technical infrastructure of the business environment. Artefacts can be evaluated in terms of functionality, completeness, consistency, accuracy, performance, reliability, usability, fit with the organization, and other relevant quality attributes. Usually, the evaluation of artefacts relies on methods available in the knowledge base. The selection of evaluation methods must be matched with the relevant designed artefact and the selected evaluation metrics. For instance, descriptive methods should only apply for innovative artefacts for which other forms of evaluation may not be feasible.

3.4.4 Guideline 4: Research Contributions

Clear contribution to the domain for which the design artefact has been developed concludes an effective design-science research, design knowledge (i.e. foundations), and/or design evaluation knowledge (i.e. methodologies). The ultimate question for any design science research is: What are the new and interesting contributions? There are three potential types of research contributions: novelty, generality, and significance of the designed artefact. One or more of these contributions must be found in a given design research project. The main research contributions are from the design and foundation perspectives, proved the application of the methodology. The design artefact perspective is the contribution of design science research is the artefact itself. The artefact must enable the solution of hitherto unsolved problems. It may extend the knowledge base or apply existing knowledge in new and innovative ways. The foundation perspective refers to the fact that improvement and extension of the existing foundations in the design science knowledge by constructs, method, model, or instantiations is also an important contribution. Finally the methodology perspective of the contribution guideline examines measures and evaluation metrics that are significant components of design science research. Usage and creation of evaluation methods and metrics provide design science contribution.

3.4.5 Guideline 5: Research Rigor

Rigor refers to the fact how the research is conducted. Design science research requires rigorous methods for building and evaluating artefacts. It often relies on mathematical formalism to describe the built artefact. However, the environments in which artefacts must perform and the artefacts themselves may resist formalism. For example, some important parts of the problem may be abstracted or assumed away if one tries to be mathematically rigorous. This can be observed while applying construction activities; rigor must be adjusted to the applicability and generalizability of artefacts. The rigor is derived from the effective use of the knowledge base, theoretical foundations and research methodologies.

Moreover, artefacts are often components of a human-machine problem-solving system. For such artefacts, knowledge of behavioural theories and empirical work are necessary to construct and evaluate such artefacts. Constructs, models, methods, and instantiations must be exercised within appropriate environments. It is necessary to understand why an artefact works or does not work to enable new artefacts to be constructed that exploit the former and avoid the latter [8].

3.4.6 Guideline 6: Design as a Search Process

Research in design science is conducted in an iterative manner. Searching for the most optimal design is usually laborious for realistic information systems problems. Simon [49] pointed out that the search is essentially to discover an effective solution to a problem. Solving the problem can be achieved by utilizing available means to the research desired end. However, this should be done with the respect to the laws in that environment. The search progress is iterative in its manner as the scope of the design problem is emerging. This makes the means, ends, and laws refined and the design artefact becomes more relevant and valuable. Although construction of an artefact is based on prior theory and existing design knowledge, it may or may not be entirely clear why it works or the extent of its generalizability [151]. Understanding why an artefact works is crucial; however, the environment in which the artefact does work should not be underestimated and be characterized substantially. Artefacts should enable IS practitioners to explore the artefact in-depth which in turn should provide a context for additional research aims in order to fully explain the resultant phenomena [57].

3.4.7 Guideline 7: Communication of Research

Communication of the design science artefact aims at technology-oriented as well as management oriented audiences. The former can explore the benefits offered by the artefact which in turn may enable researchers to build a cumulative knowledge base for further extension and evaluation. Hence, it is also imperative to explain substantially the functionality and evaluation methods of the artefact to the audience. Communication to the latter audience should provide enough details to determine if the organizational resources should be committed to using the artefact within their specific organizational context. Zmud [152] pointed out that presentation of an artefact requires an emphasis not on the nature of the artefact, but on the knowledge required to effectively apply it. The focus should be on specific contexts for individual or organizational gain. That is, the importance of the problem and the novelty and effectiveness of the solution offered by the artefact should be explicitly underlined.

3.4.8 Application of Research Guidelines

In this research, the design as an artefact guideline takes into account people, organisation and technology applicable to the research problem. The innovative artefact takes form of a reference model and associated research practices that allow researchers to build business process model artefacts. The construction of the artefact employed systematic literature review, collaboration with practitioners in form of focus groups and one to one interviews accompanied with Business Process Modelling Notation (BPMN). The literature and practitioners provided a systematic approach to build relevant and rigours artefact. BPMN provided a notation that support design and development of process models that can be further analysed and interpreted by business. Chapter 4 expands that further.

The problem relevance guideline undertakes construction gap of activities in meta-design phase of design science research methodology. The lack of activities at the operational level and different views are demonstrated in the literature (see Chapter 2). The relevance of reference model proposed for both the business side (see section 1.4) and design science community has been approach by means of focus groups, interviews and relevant design science literature. This provided the components and limitations for the construction of the artefact discussed in chapters 4 and 6 accordingly.

Design evaluation guideline is applied by observational and experimental methods to evaluate the utility and quality of the reference model. This involved field experiment design with research students who were asked to develop business process model artefacts. Another experiment was with the users for whose the artefacts were developed. Finally, case studies with various organizations were conducted to study the reference model in more complex business environment. This was to examine if the reference model is capable to meet its objectives (see section 1.4). The ability to creatively vary the design process, within the limits of satisfactory constraints and challenges adds value to designers who participate in the research work.

Research contribution guideline in terms of the design artefact, it is showed by application of existing knowledge shaped into the reference model. It enhances the field of design science research by providing specific process oriented and general activities inferred for the application of meta-design phase in design science methodology. The foundation perspective of this research discovers and employs design science activities for the purpose of construction of the reference model. This extends the knowledge with respect to research problem of lack of specificity for meta-design phase in design science methodology. Moreover, this research work extends the knowledge of selected methods for the purpose of business process model research. Finally, the methodology perspective is outlined on the Figure 3.3. The right-facing arrow at the bottom of the Figure 3.3 from IS Research to the knowledge base indicates these contributions. This research combined a number of evaluation methods: case study, experimental design, and questionnaire as a self-report. The combination of evaluation methods for the reference model contributes to the knowledge base in terms of application to design science research.

To ensure that the reference model artefact attain the research rigour guideline appropriate methods were employed. Methods discovered among other design science research projects were adopted. This research used systematic literature review, focus groups, and interviews for the construction of the reference model (see chapter 4). This accommodated a systematic approach and principles of design science. The iterative approach to all these methods was significantly employed.

The design as a research process guideline is met by referring to the iterative approach. It enabled for refinement of the reference model and its application. The exact iteration of the construction of the artefact is extended in section 3.5.1 and then in Chapter 4. This research focused on the practical application of the model as well as its capability of adaptation for other types of artefacts.

The communication guideline was addressed by providing a description in detail of the process reference model for both technical and organisational audience. The design of the model in business process modelling language (BPMN 2.0) enables the IS practitioners for its quick implementation as well as its refinement in the rapidly changing IS environment. This work was presented to the IS and design science community [56,153,154,155,156]

3.5 Research Design

This section presents methods selected to address research questions. As mentioned in section 3.1, this research combines quantitative and qualitative research methods. Researchers identified three main reasons that favour such combination. First, it is used to enable confirmation of each other through triangulation. Second, it enables to develop analysis in order to provide richer data. Third, combinations may initiate new modes of thinking by attending to paradoxes that emerge from the two data sources [157].

Design science focuses on creations of artefacts. It addresses research through the *building* and *evaluation* of artefacts designed to meet identified objectives [8]. Understanding the nature and causes of these objectives can be a great help in designing solutions; however, design science does not limit itself to the understanding, but also aims to develop knowledge on the advantages and disadvantages of alternative solutions [50]. Hence, this research is divided into two major sections: build and evaluate. The former followed systematic literature review and collaborated with practitioners by forming a focus group and conducting interviews. The latter was conducted by experiments supported with questionnaires to validate the relationship between the outcomes of the reference model artefact and its representational information quality, and case studies to demonstrate how the reference model operates in complex research environment. Figure 3.3 illustrates where these methods are employed with the respect to the design science research framework.

3.5.1 Build

The discussion and findings, regarding design science research methodology in chapter 2, demonstrated its lack of specificity for operational activities in its meta-design phase. The main focus of this work was put on business process model artefacts. The research theme ‘Construction’ constitutes one of the leading problems of this research: How to consolidate different views of the meta-design phase to build the reference model? It was established that design research produces artefacts in different forms in the meta-design phase (see Figure 2.3). These could be a construct, model, method. [53]. As stated in chapter 2, the constructs are abstracted concepts aimed for theorizing and trans-situational use. Models represent the connection between problem and solution components enabling exploration of the effects of design decisions and changes in the real world [8]. Methods are defined as a set of phases (e.g. guideline) to perform a task [53].

The section 2.2 outlined that one of this research goals is to provide activities required to build meta-design knowledge. That is, the reference model aims to detail activities required to build a construct, model, and method of a process artefact sought. The sections 2.2.5 analysed and identified three core areas from which detailed activities should be derived. These were systematic literature review, collaboration with practitioners and information modelling. Having established importance of these activities, they were used to build first the construct, then a model, and eventually methods of the reference model. Figure 3.4 combines all the above-mentioned findings into a conceptual framework for the meta-design phase which constitutes the base scheme for the reference model.

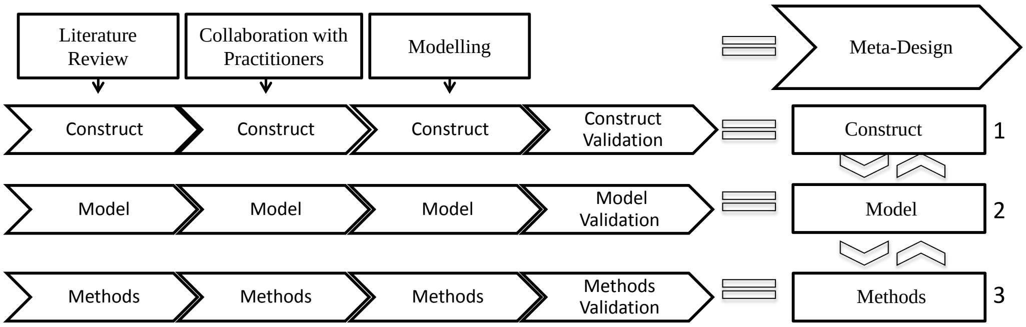

Figure 3.4 Conceptual Framework for the Reference Model [154]

Figure 3.5 outlines how the identified meta-design activities are mutually dependent and therefore are approached simultaneously for each of the outcome of the conceptual framework, construct, model, and method. In the following, it is presented how the conceptual framework deals with this challenge.

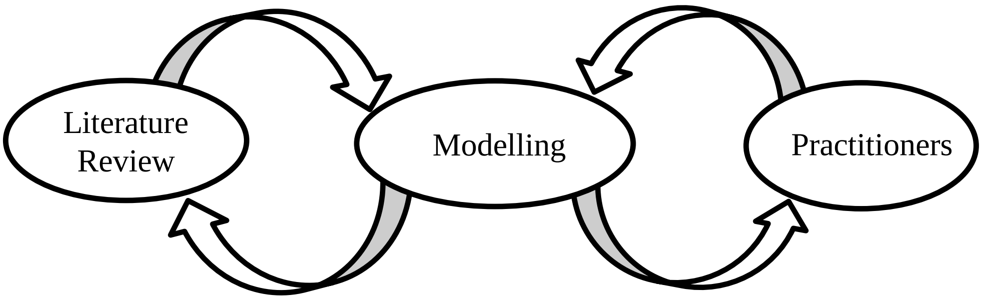

Figure 3.5 Main Activities in the meta-design phase [154]

The rationale behind the framework, illustrated in Figure 3.4, is to apply theories of disciplines of the three activities to the relevant layers (i.e. construct, model, or method) of the artefact of interest, and then combine. This refers to the definition of IS which is the applied research discipline [7]. In the sense, that we frequently apply theory from other disciplines, such as economics, computer science, and the social sciences, to solve problems at the intersection of information technology and organizations [7]. Thus, the combination of these three activities can be produced by comparing multiple plausible models of reality, which are essential for developing reliable scientific knowledge [158]. However, this combination still needs redesigning to fit the purpose of the output in meta-design phase, which are the process model artefacts. This is the rationale behind the conceptual framework. For example, one intuitively reaches for plausible constructs in domains of literature review, collaboration with practitioners, and modelling. Then, it analyses these domains for a purpose of a common construct for the reference model, and combine, so that in a result it gets a general construct of domains on how to carry out these three activities all together. Upon having the construct, it decomposes its domains into the model layer. Subsequently, having established the model layer it uses it for the method layer. The framework enables build an artefact that provides substantial guidelines on how to conduct literature review, collaboration with practitioners, and relevant modelling techniques for business process model artefacts in the meta-design phase. By following the conceptual framework, it was possible to discover and apply not only relevant methods for the activities abovementioned but also implement these that meet the research objectives into the reference model. By using activities in one layer to develop another layer, the activities used are already validated. Therefore, the validation part appears in the framework. For example, as activities and theories on the model layer of the systematic literature review are learnt, only activities applicable and matching objectives of the reference model are embedded into the reference model, while they are carried out for this phase. Then, these activities are used to gather information on the model layer of the collaboration with practitioners phase. Moreover, practitioners are engaged to provide practical experience on the two model layers: literature review and collaboration. By following this iteration, practical and academic perspectives are achieved for activities of the reference model [154] and its consecutive layers.

As established in the discussion in the chapter 2, literature review and collaboration with practitioners are the main sources of information for the construction of meta-design outcomes, and the modelling is to present the findings in a combined fashion. At the same time, these three activities are the ones that need further decomposition to operational activities in order to build the reference model in meta-design phase. Table 3.3 shows a template which was used to present the operational activities of the reference model in chapter 4. In this chapter each activity is discussed in terms of its construct, model and method layer. For the construct layer, components of the activity and their sources of information: literature or collaboration with practitioners are presented. The model layer shows the relationships between components, which puts together, constitute a method described accordingly. In addition, evaluation perspectives are outlined for the activity. The relevant evaluation perspectives are discussed in chapter 5.

Table 3.3 Template for Identified Detailed Reference Model Activities - Components

Activity A	**Construct**	**Model**	**Method**
Literature	component 1	Model of component 1 & 2	Description of combined components 1 & 2
Collaboration	component 2		
Evaluation	application of component 1 & 2 in evaluation perspectives		

The following sub-sections introduce the general approach to the three main activities undertaken in this research: literature, collaboration and modelling. As discussed in this chapter, systematic literature review, focus groups and interviews were employed to collect information. Interviews and focus groups became the main methods representing collaboration in this research; hence, they are introduced separately. The main effort in information modelling is on business processes, which is in line with the research objectives of the business process model artefacts. The purpose of the modelling was to enable the information gathered being kept in a business process shape.

Systematic Literature Review

Literature research in design science is used to review the state-of-the-art concerning the research problem or to analyse possible difficulties and complications for its solution. In addition, publications coming from the explanation and prediction theory approach can provide supplementary insights into a possible artefact design. Keeping track of current activities in IS enables researchers react to changing trends in IT market as well as in research findings [34]. Researchers pointed out that design artefacts may significantly benefit from an effective methodological literature review [42,68]. The vital idea behind it is that the literature review is not just one distinct phase in a research task. It is both a phase and an iterative feedback loop. A concrete scope of the artefact determines what kind of literature is appropriate, and performing a literature review helps build the artefact to solve a problem [159]. Thus, one of main methods to build the reference model was systematic literature review. It began with potentially relevant citations gradually reaching towards other relevant publications, and paying particular attention to design science process related special issues and conferences. Closer attention was paid to papers largely methodological, as well as articles that are methodological in part only that then can be shaped into process oriented activities.

Researchers [42] pointed out that an effective and quality literature review is one that is based upon a concept-centric rather than chronological or author-centric approach. This is to avoid a pile of citations and findings that are impressive but not much plot can be concluded. The key is to ensure that the researcher gain a full understanding of the body of knowledge related to the artefact, while at the same time the researcher is given space for their own explanatory and creativity regarding the design science artefact investigated [45]. Some of the features that differentiate a systematic review from a conventional literature review can be formulated as follows [160]:

- Scope of the research is defined and specifies questions being addressed.
- A search strategy is defined to detect as much of relevant literature as possible
- Search documentation is assessed by rigour, completeness and repeatability
- It contains explicit inclusion and exclusion criteria to assess each potential study.

However, one of the negative aspects of this method refers to researchers new in the field. They common assumptions that the current area of investigation emerged in recent years, when in fact, it has long roots in the past that continue to have a major impact on current practice. At many occasions, much valuable information is missed if the researcher checks only sources in their own discipline. [161]. Inexperienced researcher tends to describe specific publications as opposed to retrieve only the relevant information. There is no agreed definition of quality of information in materials retrieved [160]. The CRD Guidelines [162] and the Cochrane Reviewers' Handbook [163] both suggest that quality relates to the extent to which the study minimises bias and maximises internal and external validity. Table 3.4 summarizes definitions of key quality terms for evaluating quality of materials and their contents.

Table 3.4 Quality concept definitions [160]

Term	Definition
Bias	A tendency to produce results that depart systematically from the 'true' results. Unbiased results are internally valid
Validity	The extent to which the design and conduct of the study are likely to prevent systematic error. Internal validity is a prerequisite for external validity.
Applicability	The extent to which the effects observed in the study are applicable outside of the study.

Figure 3.6 illustrates the approach to systematic selection of literature. The section 4.2 presents operational methods of literature review for the purpose of the reference model.

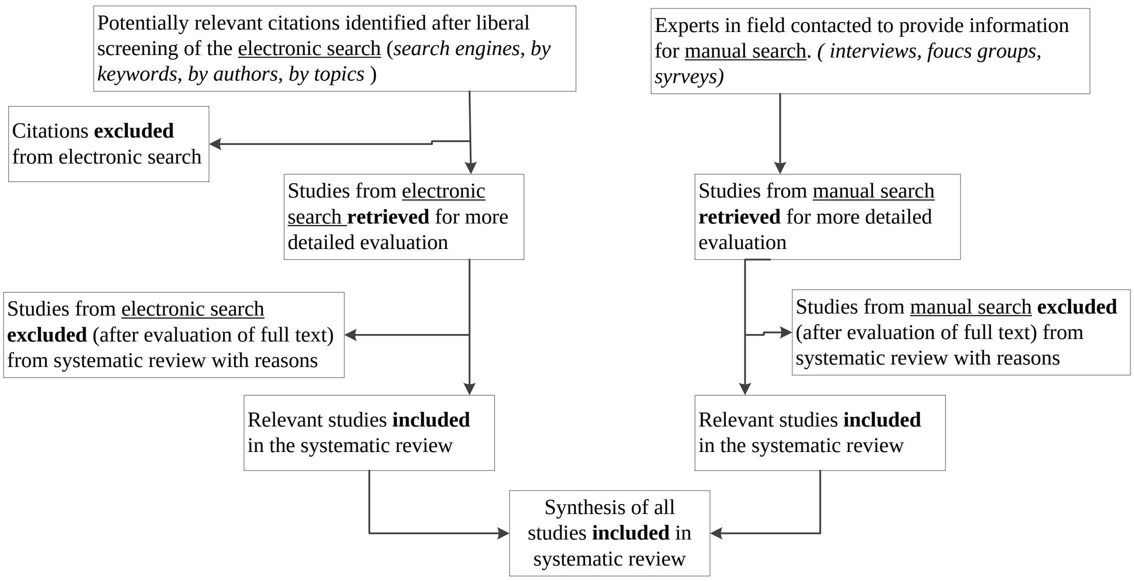

Figure 3.6 Flow Diagram of study selection procedure, adapted from [164]

Interviews

The qualitative interview method is the most widely and extensively used in multiple disciplines [165], including design science research. It was employed in this research due to the ability to gather and clarify people's experiential life “as it is lived, felt, undergone, made sense of and accomplished by human beings” [166]. Practitioner’s work is mostly invisible to researchers and their experience has vertical depth for research [165]. The interview method distinguishes itself from others by engaging participants directly in a conversation with the researcher. The conversation can generate contextual and authentic accounts of participants' personal or organizational experiences. However, interviewing does not automatically guarantee the production of rich data and meaningful insights [167].

Based on references, the interview method was employed to help select participants for the focus group method, described in the following section, and gain their own experience, without any influence of the potential focus group members, regarding the construction of the reference model. The interviews were split into two parts. One was devoted to organization questions. The scope was to learn as much as possible about the interviewee’s relations to business process model in their daily work routine. The second part focuses on findings, regarding the domain of interest, derived from the first part. That scope was to elaborate further on potential process oriented activities for the reference model, and encourage the interviewee to join the process oriented focus group. With the respect to those needs the interviews were grounded in participants' own experiences; it helped keep the interview in the most relevant events and settings. By visualizing the participant's organization world and to ask questions that sought to uncover deeper layers, one can learn the organization and its business process models. It enables to weigh the completeness and plausibility of the participant's account more accurately, thus making inconsistencies and contradictions more visible [168]. In addition, having the interview grounded in the events personally linked to participants, the risk of moving the interview into abstractions or generalities was reduced. A well-structured interview enabled the participants to articulate and interpret their experiences: in order to help the interviewee access their lived experience and reflect on it. This was usually accommodated by having an interview framework [167]. The goal was to guide the participants through the questions in a way that it honours their freedom of thought and expression. By providing such structure detail-rich descriptions as well as significant and meaningful information can be obtained in a way that was less likely to be dictated by cultural scripts and established identities. This in turn let generate rich data of participant’s multiple layers of experience. However, there are certain negatives in this method. Scheduling the interview and inputting the notes for analysis may take some time. Novice interviewers may cause bias by the tone of the voice or the way a question is asked. Analysis tends to be difficult if the interviewee produce a lot of crucial information data in a short amount of time. Individual interviews usually cost more per interview than other research methods. Further characteristics of application of the interview method for purpose of business process model construction in design science is outlined in section 4.3

Focus Groups

Focus groups offer researchers a flexible range of practices that can be useful at the various stages of an iterative design process, thus providing a consistent and encompassing research method supporting the full design process [169]. For instance, focus groups are useful for the determination of user needs (at the research objectives stage), they can be used equally well for contribution to the design prototypes (during the design stage), and finally for the testing of final solutions (at the post-design stage). It was employed in this research to help construct and determine activities for the reference model – the design stage.

Focus groups allow participants to react to other group members and to generate new ideas that might have not been uncovered in individual interviews. Thus, a focus group of practitioners was established to provide a reasonably rich data set and importantly to allows the researcher to draw conclusions about contrasts or similarities of different process activities in the collective opinions across the individuals as well as the depth of dissenting opinions within groups [170]. Researchers may engage practitioners with focus groups at a number of different levels: (1) as an observer through monitoring the sessions, (2) as a contributor by providing responses to participants' questions during the sessions, (3) as a participant by actively taking part in the sessions, (4) as a facilitator by working directly in participatory workshops, or (5) as a focus group moderator [171]. Due to the open-ended nature of focus groups, moderation can be complex. The following attributes, proposed by [172] Krueger et al., deem important when moderating a focus group: (1) presenting a friendly manner and a sense of humour, (2) involving and allowing all participants the opportunity to express their views, (3) challenging participants to draw out differences in opinions and to tease out a diverse range of meanings, (4) communicating clearly, both orally and in writing, and (5) listening to the views of others, while controlling personal views.

Suthers [173] identifies three situations involving practitioners to construct and manipulate shared information. First, they initiate negotiations of meaning among themselves so that everyone who wishes to add to or modify the state of art feel obliged to negotiate agreement with the others. This is to contribute to a common language of understanding among people involved. Second, they support conversations through components of the negotiated information evoke in the minds of others rich meanings beyond the obviousness. These components can serve as an easy way to refer to the ideas previously developed. Third, it is a reminder of common ground, whereby the negotiated information serves as a group memory and reminds the group members of previous ideas and possibly serving as an agenda for further work. Thus, the collaboration is a dialectic process in which the goal is not to force solutions on practitioners but instead to create an environment for dialog that results in solutions reached through compromise. One of the negative aspects of focus group method may emerge from the disagreements and irrelevant discussion. Practitioners pointed out that that some participants may find a focus group situation intimidating and discourage from critical discussion. At the other occasion they tend to be difficult to encourage vital practitioners to participate.

To manage a situation when participants had different opinions on the process activities, Supporting methods were employed and adjusted for the business process model discussions. It was assumed that different groups analysing the same data should often come to the same results [174]. Thus, the supporting methods enabled large numbers of ideas stemming from participants to be sorted into groups, based on their natural relationships. Then, these ideas of process activities were voted and ranked by participants so that only the most important ones get under review and further analysis. In this research, participants of the focus group were coming from the research corporate partner, its business partners, and academia. Focus group meetings were held mostly every week to discuss and revise the emerging reference model. The complete application of the focus group and supporting methods for business process model artefacts in design science research are outlined in section 4.3

Modelling

Literature [175] suggests that the most desirable modelling technique for business processes should be expressive and formal enough but easily understandable by final users and not only by domain experts faced out. Researchers indicate that the state-of-the-art in the business process modelling is represented by Business Process Model and Notation (BPMN). The primary goal of BPMN is to provide a notation that is readily understandable by business users, ranging from the business analysts who sketch the initial drafts of the processes to the technical developers responsible for actually implementing them, and finally to the business staff deploying and monitoring such processes [176].

Another possibility for process modelling could be Petri Net [177] which is designed for modelling, analysis and simulation of dynamic systems with concurrent and nondeterministic procedures. Petri Nets are utilised for modelling workflows. A Petri Net is a directed graph that mainly consists of two different nodes, places and transitions. Places represent possible states of the system. Transitions are events or actions which cause the change of state. In literature, Event Driven Process Chain (EPC) [178] has been pointed out to focus on modelling business processes with the goal to be easily understood and used by business people. The basic elements of EPC are functions and events. Functions model the activities of a business process, while events are created by processing functions or by actors outside of the model. Finally, some researchers suggested using Integrated Definition Method 3 (IDM3) [179] which is designed to model business processes and sequences of a system. It provides two perspectives: the process schematics (model of the process sequence) and the object schematics (model of objects and their changing states throughout a particular process).

Upon application of the techniques abovementioned to the representational model of Bunge-Wand-Weber ontology (BWW) [180], the advancement of BPMN was observed. The BWW model is understood to contain all necessary constructs to describe things, and the interaction between things, in the real world. In addition it was developed specifically for the IS domain, has a formal specification, and an established track record in the process modelling domain. Over the last two decades the model has achieved a good level of maturity, adoption and dissemination, allowing considering existing BWW analyses of process modelling techniques. Appendix 6 [181] outlines how these process modelling techniques complement each other based on BWW ontology. It is worth noticing that full completeness of BWW representation cannot yet be achieved, however, BPMN is the closest and thus suggested to use in the process-oriented reference model. In addition, survey results, conducted on a global scale by a research group at Queensland University of Technology [182], revealed the practical usage of BPMN in business and IT communities. 51% of respondents stated to be using BPMN for business purposes (process documentation, improvement, business analysis, and stakeholder communication) while the remaining 49% used BPMN for more technical purposes (such as process simulation, service analysis and workflow engineering).

Elements of BPMN can be split into four diagrams: 1) Flow Objects, 2) Connecting Objects, 3) Swimlanes, and 4) Artefacts [175,183]. Figure 3.7 illustrates the content of the four diagrams, which are described below.

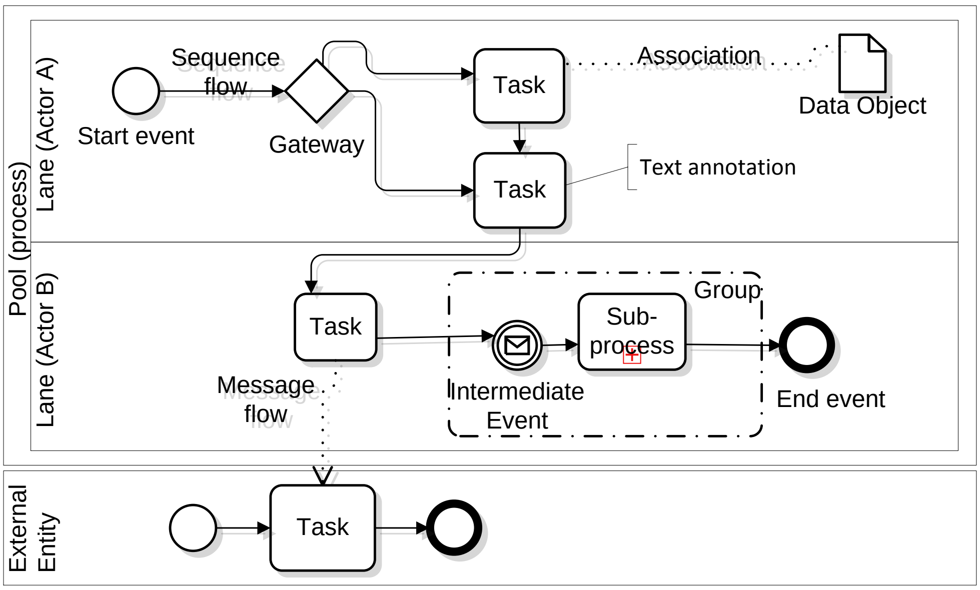

Figure 3.7 Business Process Modelling Notation – the Core Elements [175]

Flow Objects represent all the actions which can happen inside a business process determining its behaviour. They consist of:

- Events which are something that happen during the course of a business process. These Events affect the flow of a process and usually have a trigger or a result. They can start, interrupt, or end the flow
- Activities which represent work that is performed within a business process. An activity can be atomic (a task) or non-atomic (compound sub-process). They can be performed once or can have internally defined loops.
- Gateways are modelling elements that are used to control how Sequence Flows interact as they converge and diverge within a process. Different internal markers indicate different types of behaviour. All Gateways both split and merge the flow if the flow does not need to be controlled, then a Gateway is not needed. Thus, a diamond represents a place where control is needed.

Connecting Objects provide three different ways of connecting various objects to each other:

- A Sequence Flow to show the order of activities to be performed in a process.
- An Association to associate objects to one another (tasks, sub-processes, objects).
- A Message Flow to show the flow of messages between two participants of process.

Swimlanes give the capability of grouping the primary modelling elements. They have two elements through which modellers can group other elements:

- Pools represent participants in the interaction with external entities. A Participant may be a business role (e.g. buyer) or a business entity (e.g. DCU).
- Lanes represent sub-partitions for the objects within a Pool. They often represent organization roles (e.g. Manager, Associate, Actor A, Actor B).

Finally, Artefacts are used to provide additional information about a process that does not affect the flow. These are:

- Data Objects to define inputs and outputs of activities, or show how a document may be changed or updated within the process.
- Text Annotations to provide additional information about a process. They can be connected to a specific object on the diagram with an association.
- Groups to highlight certain sections of a diagram without adding additional constraints for performance – as a Sub-Process would do.

Beginning from BPMN 1.2 the number of the elements increases, even though most users only make use of the core elements of BPMN to model business processes

[175]. For a complete description of BPMN elements and features refer to [183]. In the line with Figure 3.3, this research is split into build and evaluate. The following section elaborates on the latter.

3.5.2 Evaluate

Evaluation delivers evidence that an artefact developed in design science research achieves the purpose for which it was designed. Without evaluation, outcomes are unconfirmed declarations that the artefacts meet their purpose (i.e. be useful for solving a problem or making some improvement). Design science artefacts "are assessed against criteria of value or utility – does it work?" [53]. Evaluating the utility of design science artefacts can be perceived through the information system design theories [59,61] or design principles [55], which formalizes the knowledge of the utility of design science artefacts. Researchers confirm or disprove the design theory by evaluating design science artefacts [184]. A new solution should provide greater relative utility than existing artefacts that can be used to achieve the same purpose [22].

The essential aim is to rigorously demonstrate the utility of the artefact being evaluated. Rigor in design science research should be approached from two directions. One is to establish if the artefact causes an observed improvement. The second direction is to establish if the artefact works in a real situation, its effectiveness [185]. In this research the first direction was addressed by running two experiments. First experiment assessed the representational information quality of the reference model. It was examined if the model has a positive impact on the design science research, especially in the line of communication with researchers; if the activities of the model were understandable, readable, and complete. For the full assessment, a questionnaire based on representational information dimensions was used as discussed in the section 2.5.1. The second experiment also used these dimensions; however, it looked at the relations between representational information quality and the outcome of the reference model. In other words, it measured how processes developed with the reference model are perceived by stakeholders. The second rigor direction, how the artefact works in a real situation, was addressed by case studies. In this research, case studies put the reference model in complex business research scenarios as opposed to the experiments where manipulation occurred. Now, the approach to these methods is discussed

Experimental Design

Experimental designs considered one of the most rigorous of all research designs or, as the "gold standard" against which all other designs are judged [186]. Popper [187] suggested that truth of a scientific statement or theory could be tested only by comparing two hypotheses that differ in a single respect. Mill [188] indicated that by comparing two situations that differ only in the presence of the causal variable, causality could be isolated. Both Mill and Popper pointed out to the fundamental importance of controlling all factors other than the one that is of interest to the scientist. Experiments are conducted following this rationale. Mill [188] proposed that causal factors could be isolated only by comparing two conditions: one in which supposed cause is present, and one in which supposed cause is absent. The variable that researchers typically manipulate is the one they have proposed as a cause and in the simplest situation, they manipulate it by changing whether the cause is present or absent. In this research, the cause variable is the reference model. In the experiments, the model was present for one group (i.e. the experimental group), and absent for the other (i.e. the control group) [189]. One experiment was with research students who were asked to develop business process model artefacts. One group was assigned with the reference model whereas the other was not. Another experiment was with the model users to evaluate the artefacts developed with and without usage of the reference model. The outcomes of the experiments were total scores of participants rated the representational information quality of artefacts either the reference model or the business models developed with the reference model. The general question of enquiry could be summarized as how good the artefacts represent information to their stakeholders; their fitness for use. One of the negative aspects of this method is that the results may not generalize to real-life situations, and they can be expensive and time-consuming. Depending on the purpose and design of an experiment, various threats may affect the experiment manipulation: group threats, history, maturation, reactivity and experimenter effects [189].

In experiments, data can be collected in a variety of means to address the research questions. Two main categories can be distinguished: direct observation, and self-reporting by participants. In this research the self-reporting category is in the form of a questionnaire. This form enables the researcher systematically and equally collects data from all participants in order to measure and analyse the variation of outcomes of the experiments. The variable, which is assumed to affect the response variables, is manipulated by the researcher and all corresponding effects are noted [190].

Experiments are very precisely planned activities. Researchers need to ensure that the noted effect is due to the manipulation and it did not happen by chance [189]. This is expanded in the section 5.4

Questionnaire

A questionnaire belongs to the type of survey methods. It uses questions to gather information from multiple respondents by either paper-and-pencil or online-form instruments. Researchers distinguish three main types of questionnaires: an email survey, a group administrated questionnaire and respondent drop-off [186]. In this research, the group administrated questionnaire is used. This requires bringing respondents together and asks to respond to a structured sequence of questions. In convenient group settings, the researcher hands out the questionnaire to the participants and can be fairly sure of a quite high rate of responses. Moreover, if participants are unclear about meanings of questions, they can feel free to ask for clarification. The convenient group setting refers to organizational settings where is quite easy to assembly the group [186]. The research questionnaire was held in a setting of a public organization, whose research needs were in line with the scope of this research and its employees were willing to contribute as practitioners.

In the group administrated questionnaire, each participant is handed an instrument and asked to complete it while in the room as opposed to the focus group where the researcher facilitates a session. During such sessions, participants work as a group, listening to each other's comments and answering the questions. This transcript technique leaves the researcher out of the discussion and its role is only to record stated answers.

When a researcher administers a questionnaire, a subtle process starts. The process ends, once useful and accurate information is gathered from the participant to the inquirer (e.g. a researcher). The process involves a series of questions to be posed in a clear, comprehensible, and appropriate manner so that the participant can formulate and communicate the answers effectively. These answers are then recorded and analysed with expected relatively low rate of bias, errors, or misrepresentation of the participants' views. A well designed questionnaire makes sure that this chain of events is executed as smooth as possible. A good questionnaire validates itself; it works and measures what it means to measure. Although there is not a golden rule of a well-designed questionnaire, researchers proposed certain criteria for designing questionnaires. Table 3.5 outlines criteria employed to construct a questionnaire to gather data from these experiments.

Table 3.5 Designing a Questionnaire [191]

Designing a questionnaire	
(1) Decide what data you need	(6) Think about coding
(2) Select items for inclusion	(7) Prepare first draft and pre-test
(3) Design individual questions	(8) Pilot and evaluate
(4) Compose wording	(9) Perform survey
(5) Design layout	(10) Start again!

However, researchers pointed out to certain negative aspects that have to be taken into account while conducting an interview. If the questions are asked a long time after the event took place participants may forget important issues. Too standardised questions may not be possible to be explained during the process and may lead to misinterpreted answers. Finally, participants may not be willing to answer the questions. They might not wish to reveal the information or they might think that they will not benefit from responding [192].

In this research, the experiments manipulated with the reference model to assess an improvement on the representational information quality of artefacts. Hence, the questionnaire was built on the representational information quality dimensions [110]: concise representation, consistency, ease of understanding, and interpretability, as discussed in the section 2.5.1. Questions for each dimension were constructed based on their identified attributes [109]. This is further outlined in the section 5.4

Case study

A case study takes a bit more general approach to the inquiry and enables the researcher to investigate a contemporary phenomenon within its natural setting [193]. Yin [67] pointed out that this method is particularly useful when the investigator has a little possibility to control events with which the phenomenon interacts. The phenomenon in this research is the reference model in a setting of business process model artefacts.

Case studies can be approach by either single or multiple cases. The former can be split into an intrinsic and instrumental [67]. The intrinsic one is to learn about a unique phenomenon on which the researcher focuses. It requires skills in defining the uniqueness of the phenomenon and distinguishing it from all others; possibly based on a collection of features or the sequence of events. The instrumental one is to provide a general understanding of a phenomenon using a particular case. The case selected can be a simple one although a distinctive case may underline aspects that a simple case overlooked. Hence, the use of the instrumental case requires from researcher to provide rationale for using a particular case [193]. The multiple cases are to provide a general understanding of the phenomena by applying a number of instrumental case studies that either occur on the same aspect or come from multiple ones regarding the phenomena. Yin [67] referred to them as analytical generalizations as opposed to statistical generalizations. This means that if a multiple case is used, a common approach is to provide a detailed description of each case and then present the themes within the case followed by thematic analysis across cases (cross-case analysis). At the last interpretive stage, the researcher reports the lessons learned from the analysis. The number of cases is discussable. However, the researcher needs to provide a rationale for each cases used. Certain negative aspects of case studies have to be considered. The risk emerges from the fact that the collected information does not have to be suitable for generalization or useful for its intended purpose. The fact that in majority in case studies the information is collected by one person can lead to bias in data collection. Finally, it is very difficult to draw a definite cause/effect from case studies [67].

In this research, the multiple cases approach is used. The instrumental cases were conducted to examine the reference model in complex business process model oriented design science research projects. At the level of individual cases, the reference model was used to guide researchers towards artefacts of the business process research problems investigated. In other words the questions asked and findings were relevant for the individual cases. These are discussed in the section 5.5. At the cross–case discussion level, the findings and lesson lent are presented regarding the reference model and general activities inferred for the meta-design phase in design science research that the reference model outlined. It was analysed how the model match with its objectives (section 1.4) and discuss its limitations and recommendations. This is thoroughly outlined and presented in section and 5.6.

3.6 Reliability and Validity

It is often useful to examine methodological formulations from other aspects of the research to assess their adaptability to mixed methods research [194]. One appropriate and useful device used in the field of tests and measurements is partitioning of objectivity into two components: reliability and validity. “Reliability is the extent to which a measurement procedure yields the same answer however and whenever it is carried out. Validity is the extent to which is gives the correct answer” [194]. As much as possible of the parallel realization of reliability and validity refers to research objectivity. In other words reliability is the degree to which the finding is independent of fortuitous circumstances of the research, and validity is the degree to which the finding is interpreted in a correct way. Reliability and validity are not interchangeable. It is possible to obtain perfect reliability without any validity at all. Oppositely, perfect validity would assure perfect reliability for every observation, which would yield the complete and exact truth [194].

Research design is supposed not to only represent a logical set of statements but it should also justify the quality of any given design according to certain logical tests [67]. Four tests have been commonly used to establish such quality in research. These are construct validity, internal validity, external validity, and reliability [195]. Construct validity refers to identification of correct operational measures for the concepts being studied. There are several tactics to help increase this test. One is to use multiple sources of evidence, in a manner encouraging convergent and consistent lines of inquiry. Another is to maintain a chain of evidence. Research should enable an observer to trace any evidence from initial research questions to the ultimate conclusions and backwards. The evidences should be reviewed by key informants to confirm their correct interpretation.

Internal validity is to establish a causal relationship, whereby certain conditions are believed to lead to other conditions, as distinguished from false relationships [189]. However, if the study does not explore causal relationship, the internal validity refers only to the rigor with which the study was conducted (e.g. the care taken to conduct measurements, and decisions concerning what was and was not measured). Tactics that can help achieve the internal validity are for example pattern matching, explanation building, or addressed rival explanations. In this research, the main focus is put on the explanation aspects of the reference model, thus the explanation building tactic was addressed. It tries to stipulate a presumed set of casual links about the phenomenon, or 'how' or 'why', something happened. Explanation building usually occurs in a narrative form. The most effort is to explain how it reflects some theoretical significant propositions. However, in this research, the relationship between the reference model and representational information quality was established. There are several threats that can reduce internal validity in establishing such relationship. Group threats occur when experimental and control group are not only different according to the manipulated variable. Occurrence of some events may produce changes in participant’s behaviour that can bias the results. History threats refer to the participants' lives which are entirely unrelated to the manipulations of the independent variable, but may fortuitously give rise to changes similar to those expected. Another threat is maturation. Participants' perceptions may change as a consequence of development. Next is the instrument change, which may affect apparent changes merely because the measuring device has changed. Finally, the reactivity and experimenter threats which refer to the fact measuring person's perception may affect their perception [189]. To minimize that researchers keep the participants unaware of which condition the participant is in.

External validity defines the domain to which a study's findings can be generalized. The generalization is not automatic; however, the theory must be tested by replicating the findings in second or even third instances. Once such direct replications have been made, the results might be accepted as providing strong support for the theory. One possible tactic to increase the external validity is analytical generalization. The researcher is striving to generalize a particular set of results to some broader theory, the domain to which the results of single case studies can be later generalized (e.g. results of the single case study should support the theory of the reference model).

Validity is a necessary but not sufficient condition of a good research design. The second condition is reliability. It demonstrates that the operations of a study (e.g. using the reference model) can be repeated with the same results. The objective is to ensure that, if another researcher follows the same procedure as described and conducts the same activities all over again, the researcher arrives at the same findings and conclusions. Hence, the key prerequisite is to document all procedures. Without such documentation, any researcher would not even be able to repeat their own work. The general way of approaching the reliability problem is to make as many phases as operational as possible and to conduct research as if someone was about to audit the work [67]. In terms of scale reliability, some techniques such as split-half or Cronbach's alpha can be applied [189]. Reliability is the extent to which a measure (such as a focus group) is accurate and replicable. Some methods have problems to determine their reliability. For example, a focus group concerns would be whether another focus group, of similar but different people, would give similar answers. These can be lessened if questions are relatively specific. In terms of validity in this example, focus group could concern whether it is reasonably certain that people are talking about what the researcher thinks they are talking about. Focus groups tend to be strong on validity

In designing and doing research, various tactics are available to deal with these tests, though not all of the tactics occur at the same point in the research design. Some of the tactics occur during build or evaluate stage of the research. Based on the discussion regarding validity and reliability, Table 3.6 summarizes these classifications, concerned testing factors and employed solutions.

Table 3.6 Validity and Reliability of the Research Design

	DS Research	*Themes*	*Research Quality Tests*	*Factors*	*Possible Solutions*
Research Design	Build	Construction	Construct Validity	Multiple source of evidence	Literature review
					Practitioner's engagement
				Chain of evidence	Database of materials
					Transcript of meetings
					Research scope
				Reviewed by informants	Progress meetings
			Reliability	Operational phases	The reference model
	Evaluate	Impact	Internal validity	Explanation building	Seven components of the IS design theory
			External validity	Use theory	Single cases
				Use replication logic	Multiple cases
			Reliability	Repeatability	Case studies documentation
		Quality	Internal Validity	Group threats	Two condition repeated measure design & two group independent measure design
				History	
				Maturation	
				Reactivity and experimenter effects	Double blind technique
				Content validity	Information quality (IQ) dimensions
			External Validity	Number of participants	Effect size
					Statistical significance
			Reliability	Scores correlations	Cronbach's alpha

3.7 Research Design and Research Questions

This research identified three research themes (section 2.6) that reflect research problems. In this chapter individual research methods to address each of the research questions were outlined. Application of these methods to each of the research themes will enable for a comprehensive examination of the main research motivation: *Examining and evaluating meta-design phase of design science to provide reference model for construction of business process model artefacts and determine its activities for generalization of this phase.*

The configuration was completed in conjunction with the design science research framework (Figure 3.3). The alignment of the research themes and methods, not only scrutinized the approach to build business process model artefacts but also its impact on the design science research methodology. Design science offers this mixed methods research approach [8]. Table 3.7 outlines each theme, and its questions along with methods selected.

Table 3.7 Research Questions and Methods

Theme	Research Question	Method
Construction	How to consolidate different views of the meta-design phase to build the reference model?	Systematic Literature Review, Focus Groups, and Interviews *(Chapter 2 and Section 3.5.1*
	How to systematically approach construction of business process model artefacts?	The Process Oriented Reference Model *(Chapter 4)*
Quality	How the information quality representation of the reference model can be determined?	Experimental Design and Questionnaire *(Section 5.4 and Section 2.5.1)*
	What is the information quality representation of the reference model and its outcomes?	Experimental Design and Questionnaire *(Section 5.4)*
Impact	How to examine theory developed by the reference model in design science settings?	Systematic Literature Review *(Section 2.3 and Section 5.3)*
	How the outcomes of the business process model artefacts meet research objectives?	Case study and Questionnaire *(Section 5.5)*

3.8 Summary

This chapter set out an overview of the orientation of design science to research and its rationale. It enabled to employ both qualitative and quantitative methods which needed to comply with design science research principles. Based on those characteristics, a research design was presented, which primarily was split into build and evaluate parts. Each part was described substantially and covered each allocated method: systematic literature review, focus groups, interviews, experimental design, questionnaire and case study. The validity and reliability aspects of the research design were outlined. Finally, research questions to the research methods selected were aligned. In the following chapters, their applications to the research problems are described. Firstly, the focus is on the construction theme regarding building the reference model for design science research.

4 The Process Oriented Reference Model

4.1 Introduction

Previous chapters discussed the literature review and the research methodology employed in this research. This provides a conceptual foundation to address the research questions. The aim of this chapter is to describe in detail the construction and configuration of the reference model proposed for business process model artefacts in design science research. The application of the design science research framework (see Figure 3.3) and identification of core design science activities (i.e. literature review, collaboration with practitioners, and information modelling) enhance the aim of constructing the reference model at an operational level.

However, as discussed in section 2.2 literature to date does not provide much detail on how to combine and execute these three core activities in design science context [56]. Hence, the conceptual framework was introduced in section 3.5. In this chapter, the conceptual framework is applied on the core activities [154] to build the construct, model, and method layers of the reference model artefact. As outlined in chapter 1, the aim of the artefact is to guide in construction of business process model artefacts. The reference model is described by business process model itself and it contains relevant activities discovered and verified during the execution of the conceptual framework, as suitable for process model artefacts during the execution of the conceptual framework. The further description of the reference model, in the following sections, relates to the activities employed with which the reference model was constructed upon eliminating non-suitable activities. As presented in the section 3.5, the research design approach (Figure 3.4) applied is to ensure that each layer and activity of the reference model is examined. This chapter demonstrates how to iteratively apply the reference model as additional information is being discovered. This iterative capability of the model enables researchers for subsequent addition of more detailed knowledge and activities related to the business process model investigated. The design science researchers are the consumers of information provided by the reference model.

The following sections address the construction theme of this research. Initially, the phases involved in the construction of the reference model are outlined. Then it is discussed how the conceptual framework deals with design science challenges. This is followed by an outline of the model configuration and deployment. The operational phases of the model are described followed by an explanation and justification of their selections. It is followed by the descriptions the relationship between activities, their rules, data exchange and domain experts' involvement. Later in Chapter 5, it is outlined how the model was validated via experimental designs and case studies. For fully detailed description of the reference model please refer to Appendix 8.

4.1.1 The Overview of the Reference Model

The process oriented reference model combines a process of carrying out a literature review and collaboration with practitioners in order to build a business process model. These two processes are referred as source processes. Their main goals are to gather information related to the business process model investigated, and represent it in an understandable way to the stakeholders. Each of the source process delivers a business process model. To achieve a business process model that takes into account the perspectives of literature review and practitioners, these business process models are analysed and combined into a consolidated one. To facilitate the analysis and combination, the same information modelling activities are introduced in both source processes. One is the ontology engineering which structures and defines activities relevant to the business process model investigated. For example, if a researcher investigates a process of employee engagement, then the ontology engineering enables to cluster information in a meaningful way. Another modelling activity is to apply a process modelling notation to the information gathered in order to represent it in a process shape. Upon the analysis and combination, the last phase of the reference model is to document the business process model investigated. The documentation applies to both the consolidated business process model and a business model built within a source process. Under certain circumstances a researcher may only use one of the source processes to deliver a business process artefact. Thus, each source process ends by delivering a fully modelled and described process artefact in the meta-design phase of design science methodology. The reference model guides through the construction of business process model artefacts in design science settings.

Based on the discussion in chapters 2 and 3, the construct layer of the reference model can be outlined by three main activities: literature review, collaboration with practitioners and information modelling. By following the conceptual framework (Figure 3.4), key characteristics, terms and vocabulary for each activity were determined. They came from literature and collaboration sources of information (see Table 4.1). The construct layer of the reference model illustrates Figure 4.1. The following model and method layers are indicate in Table 4.1.

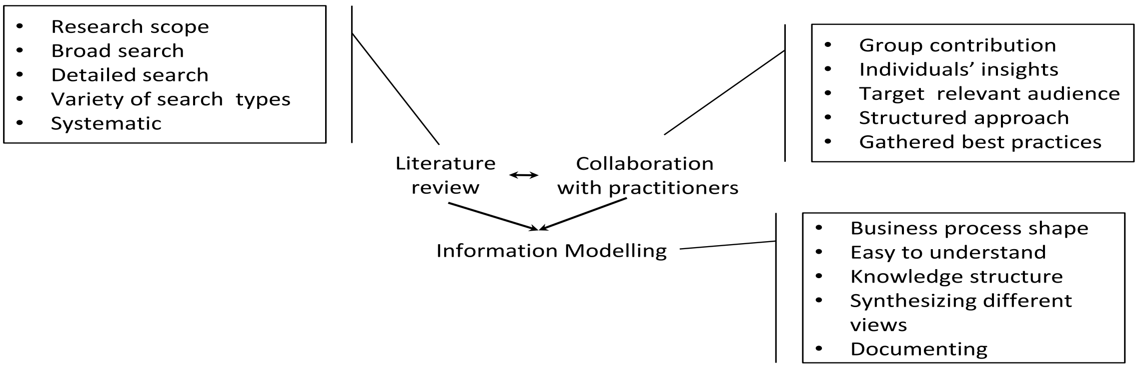

Figure 4.1 The Construct Layer of the Reference Model

In the line with the conceptual framework, the construct layer was further investigated and disclosed activities and their relations for the model layer of the reference model. This model layer shows a workflow of activities which constitute a combination of separated activities for the method layer of the reference model. Table 4.1 outlines the reference model in relation to the layers and sources of information. As discussed in section 3.5.1, each activity is summarized with an overview table that outlines the construction of the reference model.

Table 4.1 The Overview of the Layers of Reference Model

The reference model	Construct	Model	Method
Literature source	systematic, detailed search, search types, groups, relevant audience,	Figure 4.2 shows the high level overview of the reference model	The following sections 4.2, 4.3 and 4.4 provide description of activities involved in the reference model
Collaboration source	Research scope, broad search, individuals		
Evaluation	The relevant evaluation perspectives are indicated for each activity in Chapter 5		

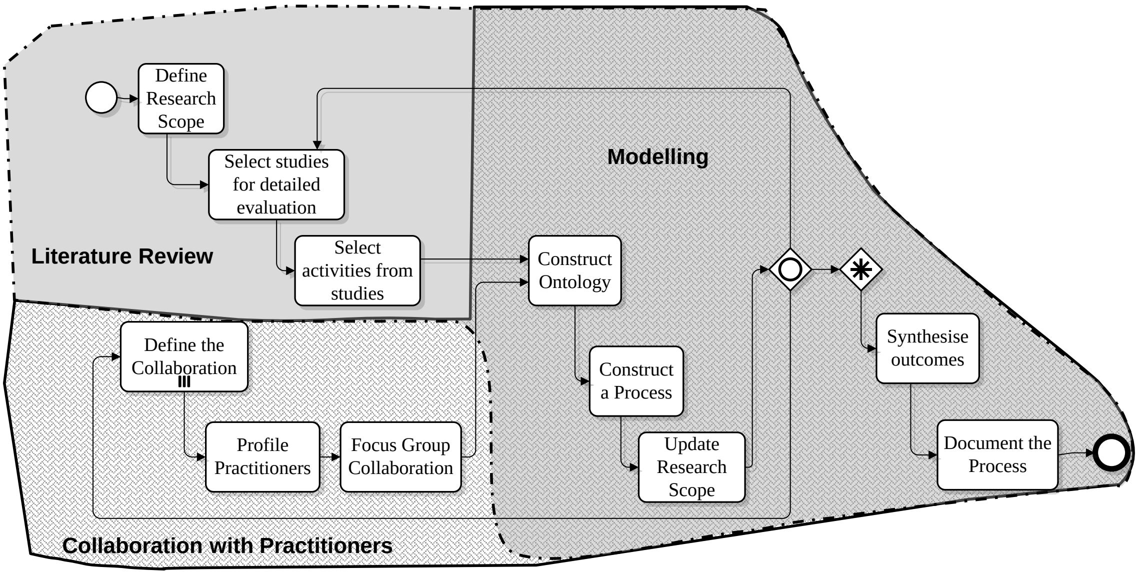

Figure 4.2 the Process-Oriented Reference Model – Overview [156]

Tasks and activities in the reference model are iterative and incremental in nature. Insights and choices in every task can affect past and future choices of tasks. For example, choices of members in a focus group are affected by the choices made in the requirements of the collaboration. If members were selected inaccurately, it would be advised to revise the collaboration requirements regarding the desired process in order not to lose the already established group. This may result in changes of the sequence of activities. While this iterative nature of the tasks involved are acknowledged, the reference model is discussed as a linear sequence of activities to keep the description straightforward. First, the focus is on the gathering information aspects of the two source processes – literature review and collaboration with practitioners. The approach is described and justification of activities selected for each of them is provided. This is to introduce the systematic way of gathering information from literature and practitioners. Second, the aspect of information modelling is introduced, which is the same for both source processes. It concerns research activities such as ontology, process modelling, process synthesis, and process documentation.

Although some activities of the reference model are applicable only to business process model artefacts, the approach represented by the reference model can be used for construction of other artefacts in meta-design phase as well. The generalization of the reference model is discussed in the section 5.6. In the following sections, the activities that constitute the execution of the three main activities (Figure 3.5) of the meta-design are justified and discussed. Their presentation follows the template introduced in section 3.5.1. For each activity, there is an elaboration on their construct, model and method layer as further decomposition of the overview of the reference model following the application of the conceptual framework.

4.2 Literature Review

As discussed in chapters 2 and 3 a systematic approach to reviewing literature helps uncover the current state of art and challenges of the business process model investigated. This section outlines a systematic approach for converting information from the numerous journal articles, conferences proceedings, books, and other qualified literature sources into a well-articulated foundation upon which business process model artefact can be built. This approach is based on a review of existing guidelines for systematic review such as: Centre for Reviews and Dissemination (CRD) - Guidelines for those carrying out or commissioning reviews [162] , Guidelines for performing systematic literature review in software engineering [160], and various articles and texts describing procedures for literature reviews in medicine and social sciences ([43], [196], [197]).

A systematic literature review involves several discrete activities. Existing guidelines for systematic reviews have slightly different suggestions about the number and order of activities. However, the medical guidelines and sociological text books are broadly in agreement about the major phases in the process. Figure 4.3 illustrates the activities of systematic literature review process in the process-oriented reference model.

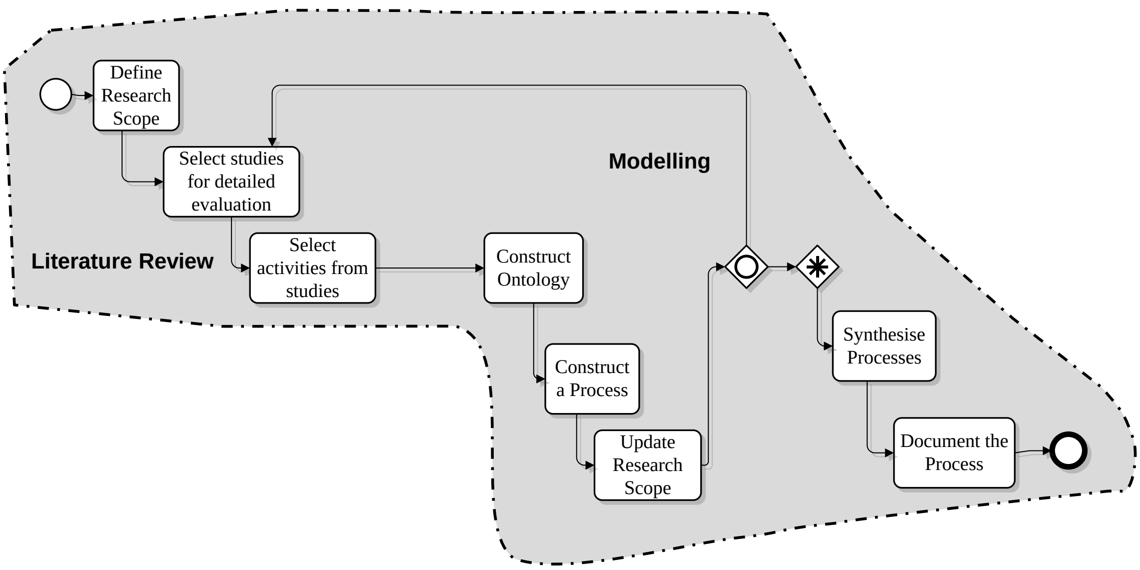

Figure 4.3 Literature Review Process [156]

Stages in Figure 4.3 can be summarized into three main phases: Define Research Scope, Gather knowledge about the process solution from literature (Select studies and activities), and Model (Construct and Synthesise) the business process model artefact. Because the modelling phase shares the same activities with the collaboration with practitioners' process (Figure 4.2), in the following sub-sections, the focus is only on the first two main phases. The third one is elaborated in detail in the modelling section 4.4

4.2.1 Define Research Scope

This is the first activity of the reference model. Its goal is to narrow down the domain in which the business process model artefact is constructed. The construct layer for this activity was defined with the following components: research idea, initial research scope, and research scope visualization. The first two components were identified in literature review, the last one was provided by practitioners during focus groups. The Figure 4.4 illustrates the model layer of these components.

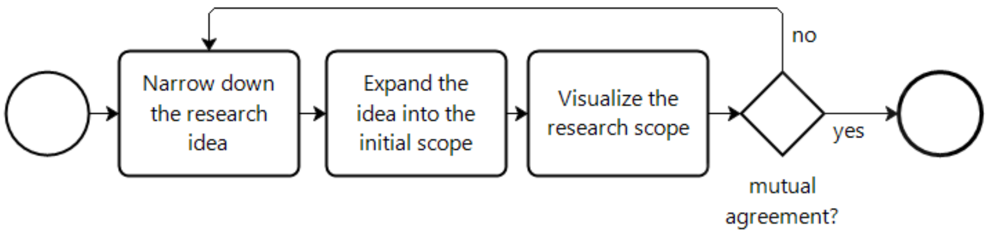

Figure 4.4 Define Research Scope Activity – model layer

Further in this section, it is described the method layer which constitutes a combination of activities for these components identified. Narrowing down the research idea requires contribution from all parties involved, e.g. the researcher, potential research supervisor, research stakeholders and/or a research originator. Generally, the research originator presents the shape and rationale of the business process model desired. The research supervisor, who usually is a senior researcher, narrows down, structures and adds additional information to the research scope. Thus the research idea turns into a shape of more researchable friendly domain. The role of the researcher, if it is not the research originator, is to participate and ask questions to clarify any ambiguity. A common agreement between parties is crucial for any further work. For instance, without clear understanding of the scope, it is possible that the selection of individual studies or the analysis may be driven by researcher's expectations. Thus, such a scope is developed in the participation of senior researcher, who has more experience in the desired domain. If, during the initial examination of a domain, it is discovered that very little evidence is likely to exist or that the topic is very broad then the domain should be cluster or decompose into the satisfactory level. Researchers indicated that this can be achieved by clustering or leaving out evidence to direct the focus of the literature review [160].

The following components of the research scope were identified by literature [160,196] and then verified within case studies. They include requirements for the literature review, state the basis for further collaboration with practitioners, and contain some additional planning information:

- The rationale for the process model to investigate and the motivation. It can contain main characteristics of the environment in which to operate.
- The main research questions that constructing the process model intend to answer.
- Expectations of the research outcome. It describes the main functionality of the process and outlines the main goals for further scoping.
- The research area, which states the area of knowledge (e.g. domain) under which the research is conducted.
- Identification of topics under the domain to provide a distinct focus for research (e.g. practitioners' engagement).
- State main objectives for each topic. Usually, a statement upon which certain topic can be approached (e.g. to summarise the best evidence on the positive and negative impacts of practitioners' engagement)
- State secondary objectives for each topic. Usually, a set of questions that must be answered in order to satisfy the topic (e.g. how to encourage practitioners for a long and sustainable collaboration?).
- Identification what may be excluded from the research. Usually, it is a set of conditions that must be avoided while researching. Elements of studies that do not fall within the range of research interest but may appear in searching.
- Identification of key authors and the relevant work. Recommended materials for research commencement.
- Identification of potential resources. It includes search terms and resources to be searched. Resources include digital libraries, specific journals, and conference proceedings. An initial mapping study can help determine an appropriate strategy.
- Project timetable. This should define the review schedule and progress.

A sample form of a scope document for a research scope including literature review is given in Appendix 2. The scope is a critical element. Researchers must agree on a procedure for evaluating the scope. This means that the scope can be given to another academic expert for review and criticism. The basic review questions, listed below, can be adapted to assist the evaluation of the literature review scope. In addition, the internal consistency of the scope can be checked to confirm that [162]:

- Do search topics appropriately cover the research questions?
- Are the inclusion and exclusion criteria correctly justified?
- Is the literature search likely to have covered all relevant aspects of the process?
- Are the objectives of the topics justified?
- Are the recommended materials likely to give the researcher a good starting point?

This research scope process includes a mind map, which is a graphical visualization of the content of the research scope. Its aim is to display the research objectives between parties. Figure 4.5 gives a sample of such mind map. The following Table 4.2 summarizes this activity in relation to its layers.

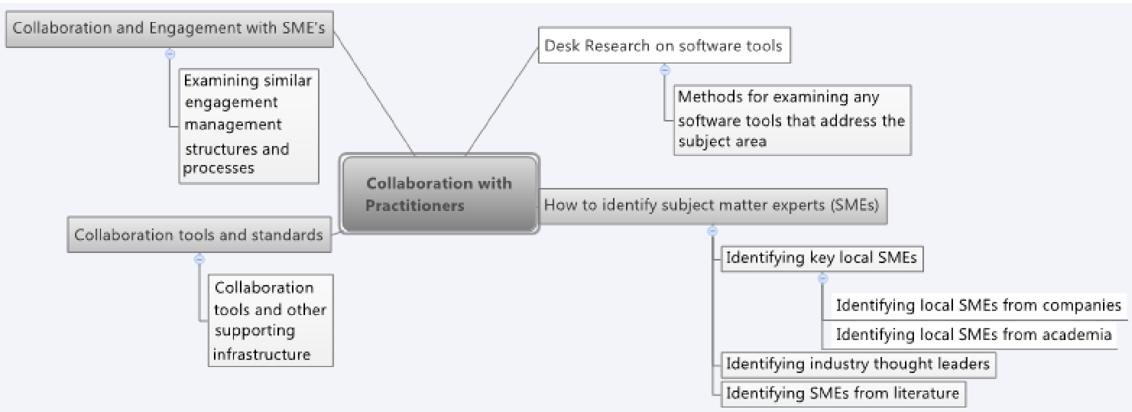

Figure 4.5 A sample of a research scope mind map

Table 4.2 The Overview of the Define Research Scope Activity

Define Research Scope	Construct	Model	Method
Literature source	Narrowing down research idea, research scope	Figure 4.4	Topics identification, main and secondary objectives, exclusion from the research, key authors, resources, timeframe, mind mapping.
Collaboration source	Visualization of the research scope (e.g. a mind map)		
Evaluation	It was applied to the first experimental design (section 5.4.2) and all case studies (section 5.5). Participants outlined the fact, the number of questions to be answered prolonged the estimated time for this activity; however, none of the parties involved claimed the undertaken research was unclear. It was discovered that visualization added transparency to the research, so that participants were able to see the hierarchy of different aspects to investigate. Engagements of all parties involved enabled reach mutual agreement in third iteration at worst.		

4.2.2 Studies for Detailed Evaluation

Define research scope activity ends when all parties involved agree on the business process model artefact to investigate. The following activity is to examine relevancy of research materials. The construct layer for this activity was defined with the following components: topics, systematic search, outcome of the search, recommended materials, and found materials document. The first three components were identified in literature review, the last two were provided by practitioners during interviews. The Figure 4.6 below illustrates the model layer of these components.

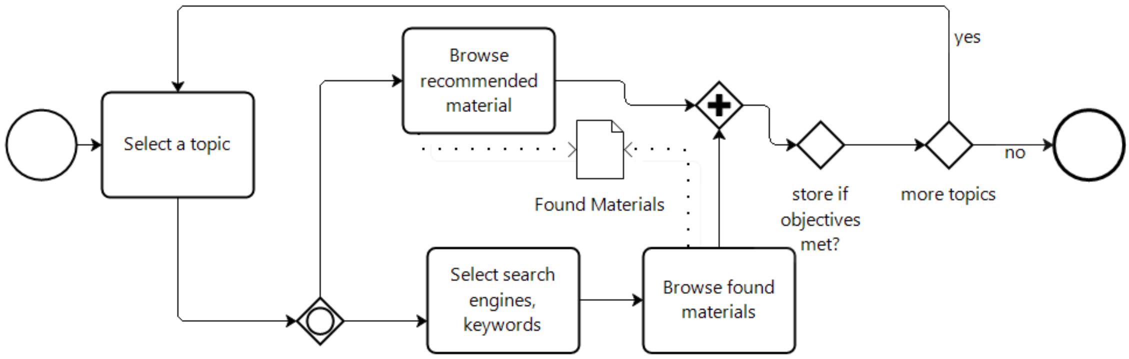

Figure 4.6 Studies for Detailed Evaluation – model layer

In this activity a researcher applies keywords to many search engines to mainly look for process relevant studies, which provide research materials and can be in various forms, such as digital libraries, journals, technical reports, work in progress, conference proceedings, research registers, etc. As a part of the research scope document, some studies are indicated to give the researcher a starting point. The main tasks here are to read abstracts, prefaces, conclusions, and references of found studies in order to collect as many potential materials relating to the research as possible. This is to select materials based on their goals and/or and summary of their contribution.

During focus groups, a general approach was determined to decompose the business process domain into individual topics stored together with a list of synonyms, alternative spellings, and abbreviations. In addition, some terms can be obtained by considering subject headings used in already found materials. Practitioners pointed out to a document in which the materials selected along with short descriptions are stored. This enables the literature review to be documented in a sufficient way that any potential readers/reviewers are able to access the thoroughness of the search. In addition, any changes to the research scope should be applied and justified as the search is carried out. It all should be saved and retained for possible reanalysis. This task can be achieved by having a found materials document. A sample structure of such document is in Appendix 3.

Literature indicated several issues to be addressed when specifying a broad search procedure [198]. There are different search approaches that enable achieving various search objectives. In the case of searching for process activities of a domain, the domain is decomposed into independent topics that shape the process at the abstract level. Each topic is justified during the definition of the research scope activity and new topics may emerge as the research progress. Moreover, knowing the publication date of the first article on a specific topic restricts the years that need to be searched. If the search is restricted to specific journals and conference proceedings this needs to be justified. Many different sources need searching; no single source contains all the key findings. A common practice is using search engines, which significantly increases the speed in findings materials. However, no all information search engines are designed to support systematic literature reviews. Researchers need to perform resource-dependent searches.

This activity ends, once all the keywords and databases specified in the research scope are checked. The design science researcher poses a list of materials grouped by topics to be fully read for the purpose of the identification of desirable process activities. The full read is also applied to obtain new leads of other potentially relevant materials. This is all achieved at the next activity. Table 4.3 summarizes the above-discussed activity in relation to its layers.

Table 4.3 The Overview of the Studies for Detailed Evaluation Activity

Studies for Detailed Evaluation	Construct	Model	Method
Literature source	topics, systematic search, outcome of the search	Figure 4.6	Identification of existing materials, assessment of the materials in relation to the objectives, combinations of various search terms derived from the research scope, storing information in structured found materials document.
Collaboration source	recommended materials, found materials document		
Evaluation	It was applied to the first experimental design (section 5.4.2) and two case studies (sections 5.5.2 and 5.5.3). It was discovered that found materials document enables transparency and traceability of collected information as well as monitoring research progress. The approach of searching by research topics helped researchers to investigate the research problems from all angles with the same granularity of information.		

4.2.3 Select Activities from Studies

At this point a list of materials, on various studies, grouped by topics is available for full reading. Topics are understood as distinguished parts of the domain in which the process is being investigated. They provide a more precise research focus (e.g. a migration of small medium enterprises to the Cloud in CRM market sector). They constitute into which facets of the domain to look.

The construct layer for this activity was defined with the following components: new references, justification of selection, full read, refer back to the broad search in studies for detailed evaluation, activity fragments, visualization and materials prioritisation. The first four components were identified in literature review, the last three were provided by practitioners during focus groups and interviews. The Figure 4.7 below illustrates the model layer of these components.

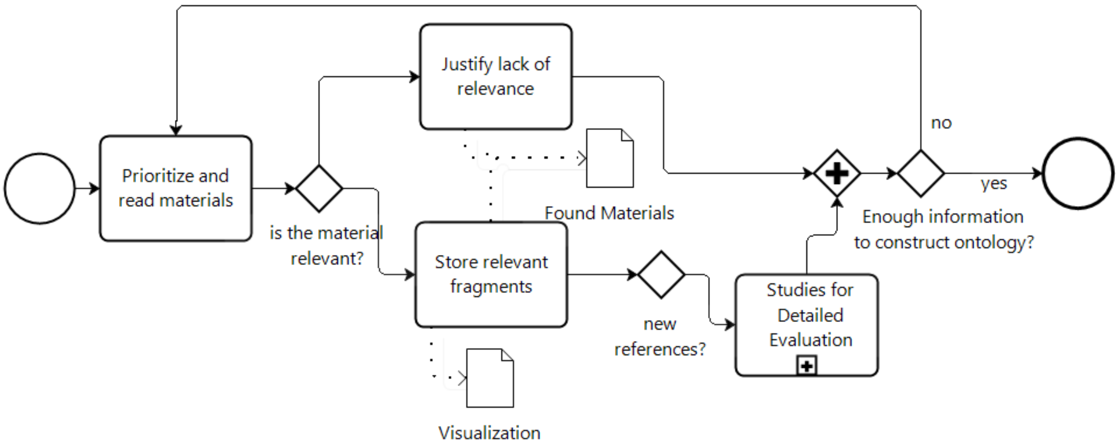

Figure 4.7 The Select Activities from Studies – model layer

During development of the research initial scope, some topics are prioritized; others can be left to be investigated in parallel. Thus the first activity is to select a topic based on the established priority and the fact how little is known about it so far. Practitioners pointed out that the key is to keep the progress of research on each topic at similar level. This helps join current findings and discover issues that may hinder linking topics in construction of the process. Next, a researcher needs to decide which material from the list to select. If the recommended materials are not available, the material that has been identified as the one that potentially best matches objectives should be retrieved.

The content of the material must be assessed for its actual relevance. Primary, secondary objectives and exclusion criteria from the research scope intend to identify those studies that provide direct evidence about process activities for the domain. In order to reduce the likelihood of bias, these criteria may be refined during the search process. In addition to these criteria, the quality of materials selected is assessed [196]:

- To examine if an explanation for differences in quality of study is provided.
- To weigh the importance of individual information when results are being analysed.
- To lead the interpretation of findings and determine the strength of results.

- To provide recommendations for further research.

As a general practice, it is recommended maintaining a list of excluded studies with the justification of exclusion. However, this is not recommended for the initial broad search for studies, which results in large numbers of totally irrelevant ones, i.e. papers that not only do not address any aspect of the research problem but also have anything do with them. Thus, the list of excluded materials should be produced while assessing the materials that made to the detailed evaluation activity. Researchers should consider discussing included and excluded materials with their advisors, an expert panel, or other researchers. They should ensure compatibility of the retrieved information by applying main and secondary objectives from the research scope document.

Materials may have many fragments regarding the same activity for the business process model investigated which are generally long. Thus, the rule of thumb is to put all desired fragments into a found materials document, for example, and provide a meaningful heading for a set of fragments, and then for each fragment a short indication to which process activity it refers (a keyword). Appendix 3 illustrates how to structure such a document. Having headings helps navigate through the findings as the amount of fragments increase while researching. Generally, each heading should represent an activity in a topic, and then each keyword from fragments state the sub-activity or description of the tasks for the activity

Practitioners of the focus group suggested introducing visualization to better comprehend what activities are already identified and how they may be linked together. For example, all headings of a material are put on a domain mind map. The aim of that is similar to the mind map of the research scope document. The mind map contains headings accordingly under each topic, so that a researcher can picture the hierarchy and dependency of the research. It helps identify the current level of progress for topics and gaps that need further work. In addition, a clear overview of the progress is very supportive while making a decision on which topic is needed more information. The domain mind map is analysed in terms of number of headings and layers of each topic. Termination of further reading takes into account researcher's experience, repetition of findings, compatibility with objectives, and lack of new insight may indicate that no more information on topics can be found. Table 4.4 summarizes the above-discussed activity in relation to its layers.

Table 4.4 The Overview of the Select Activities from Studies Activity

Select Activities from Studies	Construct	Model	Method
Literature source	new references, justification of selection, full read, refer back to the broad search in studies for detailed evaluation	Figure 4.7	Prioritization of materials in relation to the research progress and covered topics, retrieving new references during full read and switching to the broad search activity if applicable. Retrieving fragments of relevant business process model activities and visualizing them.
Collaboration source	activity fragments, visualization, materials prioritisation		
Evaluation	It was applied to the first experimental design (section 5.4.2) and two case studies (sections 5.5.2 and 5.5.3). It was discovered that putting headings of activities on a mind map enabled to spot similarities and connections between them on a regular basis. This means that lack of activities for a particular topic got clearer identified. Also describing how each material read met research objectives helped in justification of materials and further identification of activities. It was noted that design science researchers favoured the transparency of the found materials document. This is confirmed in the results of the experiment and deliverables of case studies.		

Once findings are at the satisfactory level, they need to be analysed and constructed. This is achieved by activities described in the modelling section 4.4. The following section, though, will describe the process to gather information from the second source of information – the practitioners. Similarly to the literature review process, activities required to analyse and construct findings from collaboration with practitioners process are covered in section 4.4. This is because the same activities are used in both processes.

4.3 Collaboration with Practitioners

Practitioners' best practices and expertise constitute the second source of information for the business process model artefacts. This part of the reference model focuses on working along with practitioners to discover and come up with an agreement on a general process activities emerging from various experiences. In line with the findings for activities of meta-design phase, the main goal of the literature review process is to provide information for the artefact coming from literature review, whereas collaboration with practitioners is to provide information coming from industry. Also similarly to the literature review process, the collaboration with practitioners is represented by BPMN, as discussed in section 3.5. Researchers may use knowledge gathered from literature to prepare for the collaboration, however, it has been found that not disclosing the process based on literature to practitioners at early stages keeps the collaboration open minded. The key is to concentrate on the best practices without the interference from other sources. Figure 4.8 illustrates the collaboration and modelling activities for business process model artefacts based only on practitioners input.

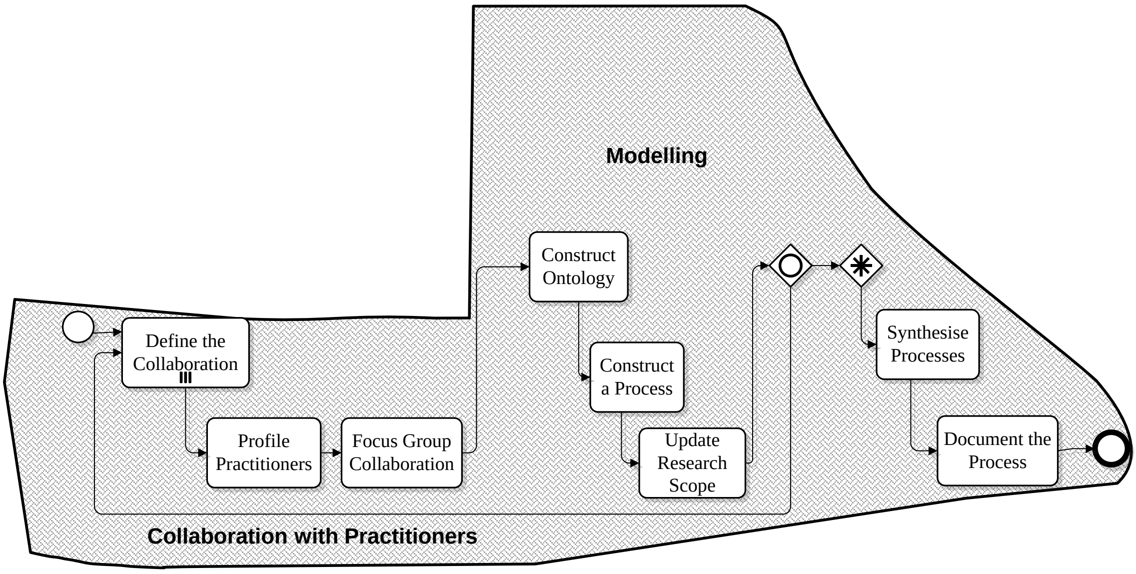

Figure 4.8 The Collaboration with Practitioners Process [156]

To build systematic development of transferable, reusable and predictable collaboration with practitioners, literature review outlined a collaboration engineering approach [199]. During the focus groups and interviews this approach was reviewed and modified to the level presented in Figure 4.9. It involves collaborative work practices that can then be used by self-sustaining communities. Figure 4.9 illustrates six activities that fall within the scope of collaboration with practitioners activity of the reference model artefact. These activities are usually not executed phase-by-phase, but iteratively. Decisions in each activity can affect decisions in former or further activities.

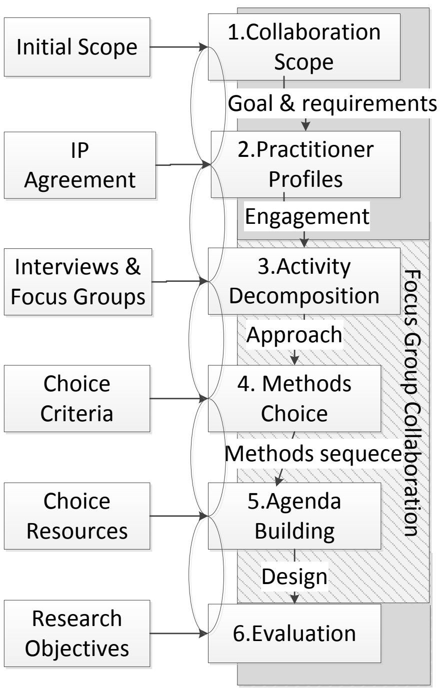

Figure 4.9 Collaboration Approach within the Reference Model, adapted from [199]

The first activity contains an analysis of the collaboration scope that the researcher needs to execute with a group of collaborators. The second activity looks into the characteristics of the collaborators and stakes involved are considered. The third activity concerns the decomposition of the collaboration scope into different activities. These activities can be performed using various collaboration methods, which are chosen in the fourth activity. In the fifth activity, the agenda for the collaboration process is built. In the collaboration with practitioners process these 3rd, 4th, and 5th activities are covered in the focus group collaboration stage (see Figure 4.8). Finally, the design of the process is evaluated to test whether it is likely to yield the desired results. This sixth activity complies with the evaluation in chapter 5 which covers application of this approach.

Similarly to the literature review process, phases of the collaboration with practitioners can be summarized into three main phases: Define Collaboration Scope (1st and 2nd activity), Gather Knowledge about the investigated process from practitioners (3rd, 4th and 5th activity), and Model (Construct and Synthesise) the business process model (see Figure 4.8). In the following sub-sections, the two first main phases are introduced. The third one is elaborated further in the modelling section 4.4 which shares the same activities with the literature review process (Figure 4.2).

4.3.1 Define the Collaboration

At this stage the research scope is already developed. Its content supports defining the number of distinguished groups of practitioners. Each group focuses on individual aspects of the process so that more insights can be obtained and discussions in groups are more precise. The distinguished groups should match the topics determined in the research scope document. The construct layer for this activity was defined with the following components: resource analysis, collaboration deliverables, attributes of desired practitioners, collaboration documentation, and research scope review. The first two components were identified in literature review, the last three were provided by practitioners during focus groups and interviews. The Figure 4.10 below illustrates the model layer of these components and Appendix 4 a sample form to execute it.

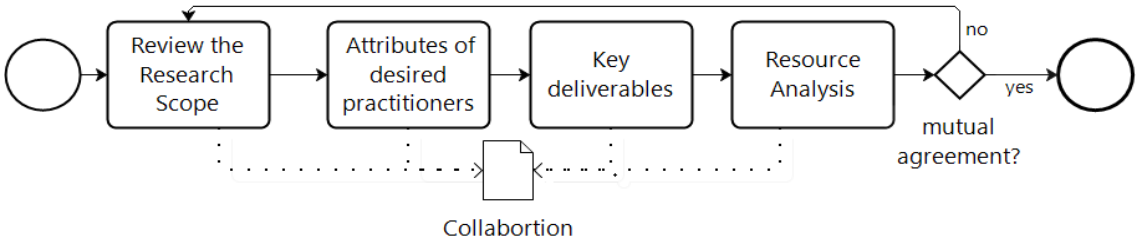

Figure 4.10 Define the Collaboration – model layer

The purpose of *profile of desired practitioners* is to have an overview of practitioners who would be the most suitable to form a collaboration group. This includes their roles, interrelationships, and individual interests. Aspects such as group size, participants' age, culture, educational background, or organization level are useful to customize the group.

The analysis of deliverables covers a definition of a topic for the collaboration from the research scope document. It consists of deliverables and the establishment of the practitioners' commitment with respect to these goals and deliverables. The topic is as a statement. The topic investigated is specific and challenging enough for the participants in order to evoke collaboration. The deliverables represent the tangible output of the process, for example, a detailed solution, a ranking of preferences, or a list of options. It has to be established what it will happen with the deliverables after they have been created [199].

The purpose of the *resource analysis* is to establish what the available resources are for the collaboration. Researchers consider the available timeframe, equipment, budget, and access to facilities either on their or companies' premise. If the availability of reliable facilities and technology is a concern, the collaboration should have instructions for the practitioners on how they can contribute with different resources e.g. pen/paper-based.

The documentation of collaboration includes the minimum requirements for the researcher to execute the collaboration with practitioners, in relation to its scope and the different settings in which the collaboration process is taking place. Table 4.5 summarizes the activity discussed above in relation to their layers.

Table 4.5 The Overview of the Define the Collaboration Activity

Define the Collaboration	Construct	Model	Method
Literature source	Resource analysis, collaboration deliverables	Figure 4.10	Getting an overview of target practitioners. Clarification of the deliverable with goals and objectives, estimating costs of collaboration and available technology for support.
Collaboration source	Practitioners' attributes, collaboration, documentation, research scope review.		
Evaluation	It was applied to the first experimental design (section 5.4.2) and two case studies (sections 5.5.1 and 5.5.2). It was discovered that availability of research scope enables to clarify the deliverables for collaboration. Resource analysis is time consuming and might be adjusted as the collaboration progresses. Availability of all research stakeholders in defining collaboration should reach agreement at one meeting. At the occasions where not everyone was present it took more meetings than one.		

4.3.2 Profile Practitioners

In the collaboration process, gathering information from practitioners is carried out in focus groups [67]. This activity aims at forming such groups of practitioners to work together on a specific aspect of the business process model investigated.

The construct layer for this activity was defined with the following components: resources allocation, contribution area, selecting practitioners, and initial conversation. The first two components were identified in the literature review, the last two were provided by practitioners during focus groups and interviews. The Figure 4.11 below illustrates the model layer of these components

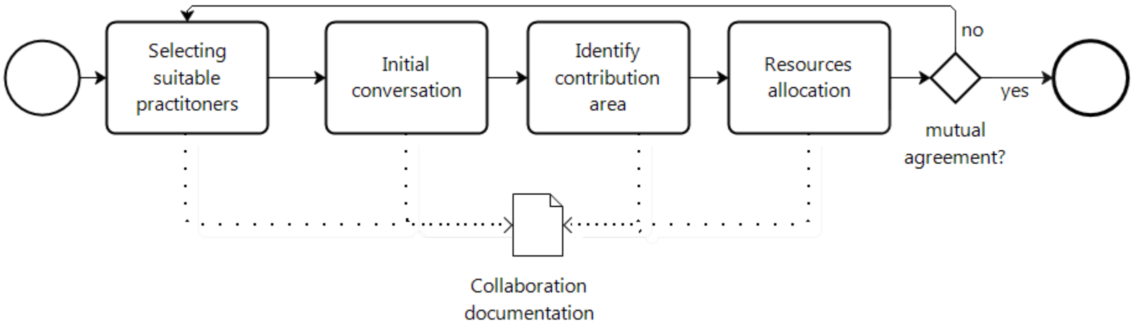

Figure 4.11 Profile Practitioners - model layer

The purpose of having practitioners in focus groups is to allow them to react to other group members and to generate new ideas that might have not been uncovered in individual interviews. Focus groups, therefore, provide a reasonably rich data set and importantly it allows the design science researcher to draw conclusions about contrasts or similarities in the collective opinions across groups as well as the depth of divided opinions within groups [170].

There is a lack of transparency in the literature regarding the appropriate number of focus group participants. The lower boundary for the number of participants is about four and the upper boundary is twelve [200]. While it can seem easier (and less expensive) to divide participants into fewer but larger focus groups, this lowers the sample size as there are then fewer groups across which to compare results.

Practitioners for the focus groups are recruited and selected based upon predefined characteristics of the collaboration (see section 4.3.1). It starts with the initial conversation with the practitioners about the research motivation and selected topics. Practitioners usually see this as a good opportunity to learn from others involved. They are asked to be involved in the collaboration to diagnose requirements, activities, and constraints of the investigated business process. It is especially important to determine whether the practitioners have congruent or conflicting interests [199]. Other aspects, to agree on can concern expectations, commitment, time and allocated budget. Table 4.6 summarizes the discussed above activity in relation to its layers.

Table 4.6 The Overview of the Profile Practitioners activity

Profile Practitioners	Construct	Model	Method
Literature source	Resources allocation, contribution area	Figure 4.11	Using predefined characteristics to recruit practitioners, during initial conversation motivation, conflict of interests and relevant topics are determined, timeframe and budget allocation.
Collaboration source	Selecting practitioners, initial conversation		
Evaluation	It was applied to the first experimental design (section 5.4.2) and two case studies (sections 5.5.1 and 5.5.2). It was discovered that motivation and goals of practitioners tend to differ and change significantly as the collaboration progresses, therefore, agreement on their expectations and desired outcomes have to be précised and outlined constantly during the collaboration.		

The activities carried out with practitioners should be documented to allow research transparency. Such documentation consists of the work agenda, methods selected, and be available to each practitioners prior the collaboration. The following section elaborates on the focus group collaboration. It describes the decomposed activities, a framework to select methods, and construction of a collaboration agenda.

4.3.3 Focus Group Collaboration

Researchers are not always knowledgeable about practitioners' experience and opinions and they, therefore, can benefit from having practitioners closely involved in research activities. Researchers may engage practitioners with focus groups at a number of different levels as discussed in the section 3.5.2. The focus group moderator approach for the design science researcher is taken here. The moderator guides anywhere between four to twelve people through a focused discussion of a specific topic regarding the process model investigated [200,201]. During this time the researcher must ensure that the focus-group session is relatively unstructured, but in reality, the researcher follow a pre-planned agenda of specific issues and set research topics to get the activities desired of the process model investigated. The researcher must ensure that all group members contribute to the discussion and must avoid letting dominate one of practitioners' opinions [169].

In the following sub-section, it is presented how to approach the complexity of facilitating a focus group. The sub-sections are divided accordingly to the Figure 4.9.

Activity Decomposition

According to the collaboration approach (Figure 4.9), decomposition of activities needed for collaboration is determined based on the collaboration scope. The details of the scope are specified in the section 4.3.1; however, the main goals and requirements of the scope stay the same for any business process model investigated using the process-oriented reference model. This is the scope to gather best practices regarding the investigated process. The best practices identify and characterize activities, input and output data, and context in which the investigated business process occurs. The focus groups decompose the business process model investigated to the level 2 at least, and each activity identified of the process is accompanied with relevant tools.

The construct layer for this activity was defined with the following components: focus group meetings, questions preparation, individual practitioner's perspective, summary and categorizing perspectives. The first component was identified in literature review, the last four were provided by practitioners during focus groups and interviews. The Figure 4.12 below illustrates the model layer of these components

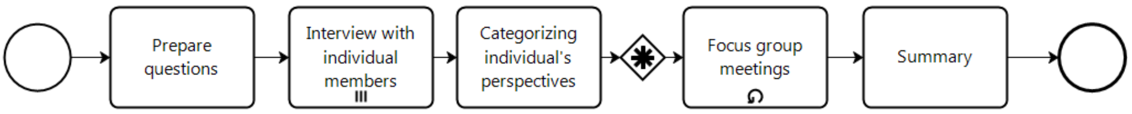

Figure 4.12 Activity Decomposition - model layer

The focus group meetings can be executed several times. Usually, the first meeting concentrates on the overall picture and collected data of the business process model investigated. The following meetings elaborate on each dedicated part of the business process model to ensure that enough time is given for sufficient insights and discussions.

Table 4.7 Activities Decomposition

Steps	*Deliverables*
Step 0. Questions preparation	
A1	Reviewing the current findings
Step 1. Individual interviews with practitioners to learn their perspectives	
B1	Understanding practitioners' expertise and context in which they approach the process
B2	Gathering process relevant activities from practitioners' context
Step 2. Categorizing perspectives	
C1	Creating a summary of practitioners' perspectives
Step 3. Focus group meetings to consolidate perspectives	
D1	Getting the participants to know each other
D2	Presenting a summary of individual perspectives
D3	Grouping matching activities from different perspectives
D4	Constructing the necessary activities for the process
D5	Consolidation of the Process
Step 4. Conclusion	
E1	Summary of the focus group achievements in relation to the scope of the collaboration.

Upon definition of the scope of the collaboration and practitioners' engagement has been confirmed, questions for the upcoming collaboration are to be prepared. This is the phase 0 because no involvement from practitioners is required. A particular attention is put on formulating the questions or assignments. Asking the right questions or the right instruction for the group is one of the most vital phases in the collaboration process. The questions and instructions should be no too complex, ensuring that the outcomes generated are relevant to the business process model investigated. [199]. To address the complexity of questions generation, they are split into two sections. First section is to understand and determine practitioners' connections to the business process model artefact under investigation in detail; the context in which they approach the artefact. Thus, the questions should be formed around their organizational units, daily activities, main responsibilities, and personal understanding of the process. The second section refers directly to the context of the business process model artefact investigated. This is the part of the process on which individual practitioners have the most expertise. Questions for this second section can only be shaped once questions of the first section are answered. However, based on the findings from the literature and the research scope, some predictions about the process and its activities can be assumed to construct general questions about the process for both sections. These questions are then decomposed into more detail ones, once a detailed context of practitioners' expertise on the business process model investigated is known.

In the step 1, interviews with each practitioner of a dedicated focus group are conducted. This step is divided into two activities (B1-B2). In B1, the goal is to understand the practitioner's work settings and facets of the process they can contribute. At this point only the first section of questions is asked. Answers can be put on a mind map in order to visualize the progress of the interview. The mind map is helpful for later analysis of the interview as well. The interview may last 40 minutes for each activity (B1 and B2) followed by a 30 minutes break. During the break the questions of section two are specified accordingly to the detailed context of practitioner's expertise. In B2, questions asked are to support the construction of the process model artefact. They should cover related key elements such as input and output data of identified activities, the order of the activities, and the performers.

In the step 2, an initial analysis of findings from interviews takes place. All practitioners' perspectives and activities of the investigated process model are summarized into meaningful categories. The categories are named by similar perspectives or activities that require the same tasks. In addition, this analysis may disclose ambiguities that need clarification before further decomposition. However, the goal is to keep clear contribution of each practitioner so that they are able to recognize their input. The summary can be then distributed to all practitioners prior to the focus group meetings. The aim is to bring into attention how much others contributed and that at the focus group meetings, even more concrete information as well as clarification of ambiguities would be given.

The following step 3 describes the focus group activities. It begins with an introduction of the agenda of the meeting followed by allocation of time for each practitioner to introduce their organisation, roles, and link to the investigated process. Then a summary of initial analysis of practitioners' perspectives is presented. During the presentation, practitioners are asked questions that help understand and further clarify all possible misinterpretation of findings of the process model presented. This may affect some process activities to be renamed, reordered, or removed from the findings. Once the summary becomes clear, practitioners along with the design science researcher, who is the facilitator of the meeting, start working on constructing the consolidated process of interest. It begins with identification and grouping similar activities starting from the initial categories introduced in the initial analysis. Practitioners, one by one, have some dedicated time with the findings of the process model to group activities in relation to their own beliefs. They are allowed to move activities to other groups and rename the groups allocated by their predecessors. Basically, when a practitioner reviews a group of someone else, which does not make sense to them, they keep rearranging the activities until the grouping make sense. Then, copies of the final shape of the activities grouped are distributed to all practitioners for the next task. This is to build a process using only the activities predefined. The goal is to provide the order in which these groups of similar activities should be executed in the business process model artefact investigated. Then, if it is possible, the practitioners are asked to provide the order of activities under each group. The ordering is done by assigning numbers to the groups and activities. Practitioners do not have to use all predefined activities or groups. Finally, the individually structured processes are discussed. At this last activity of step 3, all versions of the just constructed processes are presented and members of the focus group begin the attempt to consolidate them into one. Firstly, all groups and activities having the same order are linked together. Then, differences between groups, which have been placed in different orders, are discussed to reach consensus or specify circumstances in which each order may apply. The goal is to choose the order on which majority of practitioners can agree. The focus group meeting may last around 4 hours including 40 minutes break. For the step 4, a short 30 minutes conclusion meeting can be arranged. This is to present the consolidated process in regards to the scope of collaboration. Practitioners are provided with information on what it will happen with the results next and how they can access the findings of the collaboration. Table 4.8 summarizes the activity discussed above in relation to its layers.

Table 4.8 The Overview of the Activity Decomposition activity

<table>
<tr><th>Activity Decomposition</th><th>Construct</th><th>Model</th><th>Method</th></tr>
<tr><td>Literature source</td><td>Focus groups meetings</td><td rowspan="2">Figure 4.12</td><td rowspan="2">Preparation of questions according to the collaboration scope and practitioners background, gaining deep understanding of individual's perspective to the problem, sharing all individuals' perspectives and building a common one.</td></tr>
<tr><td>Collaboration source</td><td>Questions preparation, individual practitioner's perspective, summary and categorizing perspectives</td></tr>
<tr><td>Evaluation</td><td colspan="3">It was applied to the first experimental design (section 5.4.2) and two case studies (sections 5.5.1 and 5.5.2). It was discovered that individual interviews not only help understand practitioner's relevant expertise but also provide additional information on areas for further discussions during focus group meetings. Reporting on current progress and scopes for each meeting helped keep the collaboration transparent and this was pointed out by practitioners at many occasions.</td></tr>
</table>

Circumstances may have impact on how the activities above-mentioned are executed. Sometimes, some adjustments may be required to achieve the collaboration scope. Thus, only general descriptions and goals of activities are sketched. Execution is therefore independent of the decomposed activities of collaboration. However, without the activities, it would not be possible to select among methods because they are meant to execute the activities of collaboration. Likewise, it would not be possible to select tools without selecting the methods first. The next section presents a framework of a range of methods that can be applied to the activities presented in Table 4.7. A list of possible tools to support these methods is discussed.

Methods Choice

Methods are used to execute the activities that decomposed the collaboration scope. Without stating activities of collaboration, it would not be possible to select methods to execute them. Concerns about methods are therefore subordinate to concerns about activities of collaboration. In Table 4.7, main deliverables and the order of activities of collaboration are outlined. However, working together with practitioners requires quite of flexibility from a design science researcher. Practitioners have to give up some of their daily responsibilities and dedicate a free time, which at many occasions is changing rapidly and without much notice, to contribute to the research. In addition, practitioners' nature of work and expertise may call for different approaches to achieve deliverables of each activity. Hence, a range of methods that could lead the design science researcher to a successful execution of activities of collaboration is of much help. Even though it is possible to change the order of activities, if the circumstances require, it is recommended holding onto the order of activities (steps 0-4), manipulating only the sub-steps (e.g. B1, B2, and B3), and then choosing the desirable methods to invoke them. The key activities that require a contact with practitioners are interviews and focus group meetings. Thus, the majority of methods to select refer to these activities. These methods offer various ways of collaboration which execution aims to achieve deliverables from Table 4.7. Table 4.9 outlines the methods and highlights related sub-phases that the methods mean to cover.

The methods listed in Table 4.9 constitute the construct layer for the methods choice activity and represent its components. Practitioners pointed out to the structured interview, unstructured interview, focus group work, brainstorming, and sticky notes. The rest of the methods were identified by literature review. The references given next to the methods indicate source where further description of these methods can be found. The methods underlined are the ones used in this research work as agreed in the collaboration scope. Next paragraphs will briefly summarize the methods listed.

Table 4.9 Methods for Focus Group Collaboration

Activities / **Methods**	Step 0	Step 1		Step 2	Step 3					Step 4
	A1	B1	B2	C1	D1	D2	D3	D4	D5	E1
Laddering interview [202]	No interaction with practitioners	X	X	No interaction with practitioners						
Appreciative interview [203]		X	X							
Photo-diary interview [204]		X	X							
Structured interview [205]		X								
Semi-structured interview [206]		X	X					X		
Unstructured interview [207]		X								
Group development [208]					X		X	X	X	X
Focus group work [209]					X		X	X	X	X
KJ method [210]						X	X	X	X	
Brainstorming [211]							X	X		
Design workshops [212]						X	X	X	X	X
Sticky note [213]							X	X		
Ice breakers [214]		X			X					

Laddering interview focuses on practitioners' systems of personal constructs, which comprise elements, constructs, and links. Elements are the subject within the domain of investigation (e.g. process activities). It consists of two main phases: 1) Generating distinctions between elements, and 2) Laddering key distinctions to identify the practitioners' means–ends chain [202].

Appreciative interview is a guided introspective inquiry in a search for the best in people and the relevant world around them. The underlying premise of appreciative interviewing has two facets: 1) In human systems there is always something that can be appreciated and built upon, and 2) Grounded in elicited aptitudes and lifted with positive affect, one can effectively envision and pursue the one that is the most desired [203].

Photo-diary method, combines diaries and visual representations in support of an interview. Both enhance the interview in a way that they capture experiences and make them explicit, thereby objectifying them for later analysis. Researchers benefit of 'concrete illustrations' highlighting that they help ground the answers in the experiences of the practitioners in ways that provide nuance and precision, context, and evidence all at the same time [204].

Structured interviewing requires from a researcher to ask each practitioners the same set of questions. The order of questions is fixed and wording is usually specific: there is not much space for probing or deviating from the specified agenda. The questions and the responses are to fit into predetermined categories, confirming or disconfirming the objectives the researcher is pursuing [205].

Semi-structured interviewing offers more flexibility than structure ones. Although the researcher in this method has to establish some general topics for investigation, this method allows for the exploration of emergent areas of the investigated process and ideas rather than relying only on concepts and questions defined in advance of the interview. The researcher usually uses a structure interview schedule with set of questions which will be asked of all practitioners [206].

In unstructured interviews practitioners have the freedom to describe their experience and expertise about the subject (e.g. process) in their own way, although there may be some gentle guideline offered by the researcher in order to keep the narrative going. The researcher may have a simple schedule, but in the unstructured interviews that may not be strictly followed. The practitioners are treated as an active subject, and not merely a reporter of facts. This method is concerned with finding meanings, and attempts to develop a detailed description of the practitioners' work [207].

Group development is built on the Forming – Storming – Norming – Performing model of group development [208]. These phases have been identified as necessary for a team to grow, to face up to challenges, to tackle problems, to find solutions, to plan work, and to deliver results. It structure collaboration around a set of agreed-upon deliverables. During the collaboration, deliverables are achieved step by step referring to rules of group dynamics.

A focus group work aims to reach out to practitioners' opinions, beliefs, and attitudes about the investigated process. The use of the group is to answer questions that the researcher cannot resolve and to lead to new ideas. The work is split into 3 steps: before the group work, conducting the work, and report the results. It contains the most genuine techniques for a focus group method [209].

The KJ method enables large numbers of ideas coming from brainstorming or other sources of information to be sorted into groups, based on their natural relationships, for review and analysis. It can be used to organize notes and insights from interviews. It focuses the group on the task at hand and eliminates unnecessary discussion and distractions from the goal [210].

Brainstorming is a method that helps the researcher to generate creative solutions to a problem (e.g. identify more activities of a business process model investigated). It is particularly useful when the researcher is looking to establish patterns of thinking, so that new perspective at things can be developed. It enhances a display of diverse experience of all practitioners during the identification of process activities, for example. This increases the richness of ideas explored, meaning that the researcher can find more suitable ones for the faced problem. In addition, it can be used to overcome many of the issues that can make the collaboration a sterile and unsatisfactory process [211].

Collaborative design workshops attempt work with practitioners in order to rapidly create a shared vision. It contains three phases: 1) Business model canvas to illustrate the goal of the collaboration, 2) Customer journey maps describe people who will use the output of the collaboration (e.g. the users of the process model), 3) Design sketchboards which are a sketch based technique for sharing design concepts (e.g. the shape of the business process model investigated). This method mainly involves practitioners to sketch. It starts with a big sheet of paper that forms a large canvas on which they can explore, share and iterate on process activities. The paper is the key—it brings all the thinking together into one space. On this large sheet of paper, the investigated process can be easily decomposed into operational tasks [212].

Approach to the sticky notes method is similar to the sketchboard one. The only difference is that practitioners write a process activity on sticky notes and then attempt to link them together. The final result is a set of sticky notes illustrating the investigated process. This is the bottom-up approach as opposed to the top-down of the sketchboards [213].

Ice Breaks methods are very useful to get practitioners feel comfortable in a group setting before the main activities of the meeting take place. Actions which are not normally associated with day-to-day behaviours in the office generally make people uncomfortable. By applying ice breakers, the researcher can increase the exchange of ideas, establish team identity, and create a sense of community. All of these items are important in forging top productive teams. These methods help people to share ideas without fearing what other people will think [214].

A design science researcher carries out an activity by executing a method, which can be supported by tools. Expectations from tools are not only to afford the capabilities required to instantiate a collaboration method but also to maintain the collaboration with practitioners. Until methods have been selected, it is rather not be possible to select tools for instantiating the method because each collaboration method requires specific capabilities. Concerns about tools must therefore be subordinate to concerns about methods. If a researcher changes a method, the tool may need changing because the new method may require different capabilities. Tools are therefore dependent on methods. The advantage of collaboration tools in many cases is the ability to help a group work together despite being spread out in different geographical locations.

There are varieties of ways of application of tools to methods; hence they are not strictly matched. The possibilities by which the tools can enhance and improve application of a method can be outlined. A method can be supported by many and various tools depending on the collaboration circumstances, research budget, researcher's or practitioners' favourites. Selection of a tool is correct as long as it is capable to support application of a method. A design researcher can select and adjust a tool to meet their needs. Table 4.10 presents key features and tools found in literature and further adjusted by practitioners involved to support collaboration. The tools presented were tried and used during this research work. Upon conducting usability test of each tool in regards to the features the table was created. The 'X' indicates that a tool support a feature. Correctness of these tools is consistent with information provided by vendors for the November 2012.

Table 4.10 Features and Tools to support methods

Tools / Features for Collaboration	Office 365	Grouputer	Google Apps	ynSyte	Facilitate Pro	Meeting Sphere	ThinkTank 4	Mikogo	Comparion Suite
Conversations and Presentations									
Conference Call	X		X		X	X	X	X	X
Video Conferencing	X		X		X	X	X	X	X
Screen-Sharing	X		X		X	X	X	X	X
Agenda		X		X	X	X	X		X
Reports		X		X	X	X	X		
Voting and Prioritization		X		X	X	X	X		X
Whiteboard	X			X	X	X	X	X	X
Messaging	X	X	X	X	X	X	X	X	X
Information Sharing									
Email Discussion List	X		X		X		X		X
Social Networking	X		X						X
File Share	X		X		X	X	X		
Message Board	X		X	X	X	X	X	X	X
Archive Conversations	X	X	X	X	X	X	X	X	X
Long Term Structured Collaborations									
Project Management Tool	X		X		X		X		
Files Stored Centrally	X		X	X	X	X	X		
Wiki	X								
Blog Network	*X*		X						

Table 4.11 summarizes the above-discussed activity in relation to its layers.

Table 4.11 The Overview of the Methods Choice activity

Methods Choice	Construct	Model	Method
Literature source	Laddering, appreciative, photo-diary, semi-structured, group development, KJ method, design workshop, icebreakers	Selecting methods in relation to the settings of activities in Figure 4.12	With regards to the collaboration scope, allocated resources and agreement with practitioners, different collaboration methods can be chosen. For individual meetings with practitioners, there is a selection of interview methods. For meetings of a group of practitioners, there is a selection of collaboration methods supported by decisions making ones.
Collaboration source	structured interview, unstructured interview, focus group work, brainstorming, and sticky notes		
Evaluation	It was applied to the first experimental design (section 5.4.2) and two case studies (sections 5.5.1 and 5.5.2). It was discovered that semi-structured interview gives the flexibility to juggle between questions as practitioners' answers at many occasions were broad and descriptive whereas prescriptive answers are desired. During collaboration, researchers' additional role is to make sure that the collaboration is going towards the set goals, and individual practitioners do not use the focus group for its own needs. It was observed that reminders of the research scope and progress provide the right focus to practitioners. Structuring focus groups around KJ method gave mutually agreed outcomes which reflected the general satisfaction among practitioners and encouraged for further collaboration.		

Agenda Building

An arrangement of activities and methods does not yet represent the collaboration with the practitioners process. Careful planning of activities and definition of instructions for each of the activity is still needed. This is captured in the agenda.

The construct layer for this activity was defined with the following components: activity (from Activity Decomposition - Table 4.7), outcome, methods, time, and tools. The first four components were identified in literature review, the last one was provided by practitioners during focus groups and interviews. The Figure 4.13 below illustrates the model layer of these components

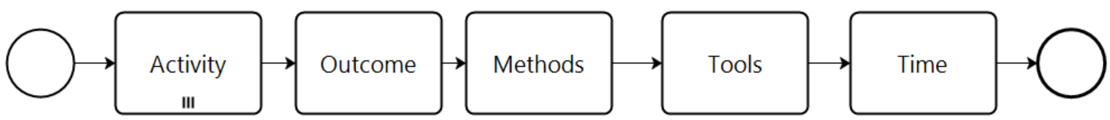

Figure 4.13 Agenda Building - model layer

This activity covers time for presentations, discussions, coffee breaks, and any other activities that a successful collaboration with specific practitioners may require. In addition, a particular attention is on formulating questions and assignments for practitioners. Asking the right questions or having the right instructions for the group is an important phase in collaboration. The questions and instructions should not be too complex, support with tools, ensure that the outcomes generated can be used as input in the next activity, and are consistent with the predefined decomposition of activities, as outlined in Figure 4.12. Agenda should be available to everybody throughout the collaboration and first introduced at the very first meeting with any practitioner. The characteristics of each component present Table 4.12.

Table 4.12 Characteristics of the agenda components

Elements	**Characteristics**
Activity	the name and description of an activity that follows in the process
Outcome	the final result of the activity
Method	the technique used to execute the activity
Tools	the software to support the method
Time	the time period needed for execution of the activity

By the structure of the reference model, a pre-defined agenda is already outlined for gathering information within the collaboration with practitioners process that aims to collect information from and build the business process model artefact with practitioners. Appendix 5 outlines the agenda, which is already formatted and filled in with the certain activities used in this work for an online collaboration case. However, the agenda should be revised and adjusted for needs of other process oriented projects. Table 4.13 summarizes the activity discussed above in relation to its layers.

Table 4.13 The Overview of the Agenda Building activity

<table>
<tr><th>Agenda Building</th><th>Construct</th><th>Model</th><th>Method</th></tr>
<tr><td>Literature source</td><td>activity, outcome, methods, time</td><td rowspan="2">Figure 4.13</td><td rowspan="2">Ensuring the order of activity execution and its outcome are transparent, selecting appropriate methods in regards to the collaboration scope and budget, scheduling the time for and breaks between methods.</td></tr>
<tr><td>Collaboration source</td><td>tools</td></tr>
<tr><td>Evaluation</td><td colspan="3">It was applied to the first experimental design (section 5.4.2) and two case studies (sections 5.5.1and 5.5.2). It was discovered that agenda available for all practitioners and outlined before each meeting helped keep the progress of the collaboration, and point to the current state. Positive responses were received from practitioners towards the agenda which was provided prior to the collaboration so that they could adjust their work obligations accordingly.</td></tr>
</table>

This section 4.3 together with the previous section 4.2 presented activities for two information source processes: literature review and collaboration with practitioners. These processes combined state the reference model. Those sections only covered Defining scope of research and Gathering information phases of the reference model. The final phase, which is the same for information gathered by either the literature review or collaboration with practitioners process (see Figure 4.2) is to model findings (i.e. the information gathered) into a business process model shape and document it. This includes research activities such as ontology, process modelling, synthesis, and documentation. These are elaborated in the following section.

4.4 Modelling

The third phase of the process-oriented reference model (see Figure 4.2) is information modelling. It concentrates on analysing information gathered, which is provided by the literature review and/or collaboration with practitioners source processes, shaping and presenting the business process model artefact investigated. In the previous sections 4.2 and 4.3, aspects of information gathering were discussed. In this section, the focus is on its rigour application for the purpose of modelling a business process model artefact. Four main modelling activities are distinguished. First one structures the knowledge base, provides semantic constraints of concepts for found information. This activity is ontology engineering as discussed in section 4.1. The second one is to model the business process model artefact based on the knowledge base built in the ontology engineering activity. The following considers combining business process model artefacts coming from both the literature review and collaboration with practitioners activities in order to provide one consolidated business process model artefact to accommodate the research problem investigated. The last activity is to document the business process model. It covers descriptions for identified activities, their goals, data and performers. Thus, the final outcome of the reference model is a documented business process model artefact that can be circulated within the stakeholders. Figure 4.14 illustrates the modelling activities abovementioned and one activity which refers to updating the research scope. A business process model artefact based only on either the literature review or one setup of the collaboration with practitioners can reveal hitherto unknown areas and topics of the domain. Thus, the research scope is reconsidered and revised. This mainly requires going through the activity described already in section 4.2.1. Hence, the following sections elaborate on constructing, synthesising and documenting the business process model activities.

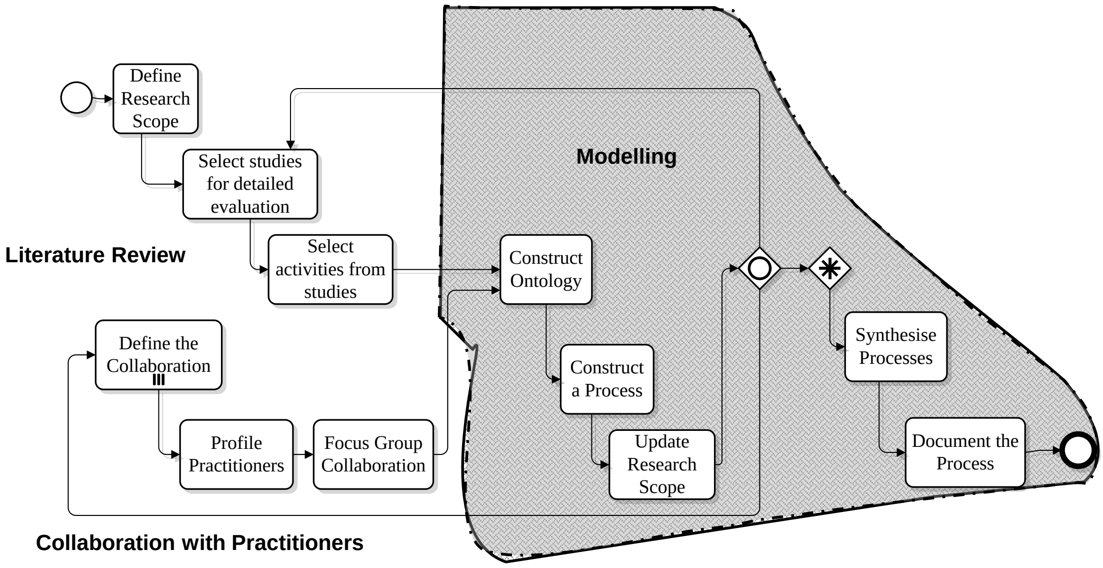

Figure 4.14 Information Modelling [156]

4.4.1 Construct Ontology

Ontology in the process-oriented reference model serves the purpose of structuring gathered information in a systematic fashion. Its aim is to create a knowledge base that contains all findings logically linked. There are many interpretations about what ontology is [134]. The understanding falls within the definition by Gruber [135] as discussed in the section 2.6.3.

The construct layer for this activity was defined with the following components: enumerate terms, define classes, properties and constraints, create instances, generate class diagram. The first five components were identified in literature review, the last one was provided by practitioners during focus groups and interviews. Figure 4.15 below illustrates the model layer of these components

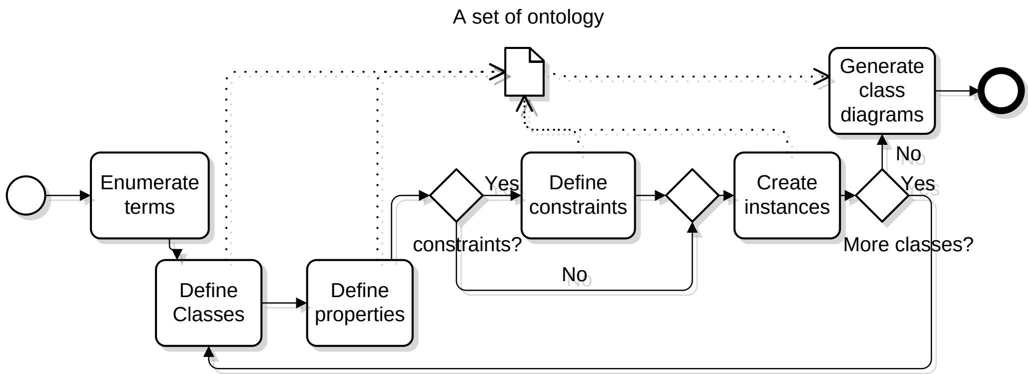

Figure 4.15 Construct Ontology – model layer [215]

Main activities of the ontology process involve determining terms of the domain and relations among them. This is achieved following definition of concepts (classes) of these terms, arranging the concepts in a hierarchy (subclass-superclass hierarchy); defining which properties each class can have and constraints on their values; creating examples of instances and filling in property values. To write the knowledge base of a domain researchers suggest language that is characterised by formal semantics and RDF/XML-based serializations – the Web Ontology Language (OWL). This is a family of knowledge representation languages for authoring ontologies [134].

The following elaborates on the activities of ontology engineering process (Figure 4.15). First activity requires awareness of terms from researchers. They need to enumerate terms necessary for the investigated process out of the information gathered; determine potential properties and meaning of each term. The idea behind it is to get a head around the domain before defining any classes. A typical example of this phase could be a set of terms (e.g. bank accounts, location, currency, saving account with 3% interest, loan). Thus, the first task in the ontology engineering process is to *enumerate terms*. Next is to *define classes and hierarchies of classes.* A class is a concept in the domain (e.g. a class of bank accounts or a class of customers). A class is a collection of elements with similar properties. Instances of classes would be for example, a saving account at 2.5 % of a customer Mr. X. Classes usually constitute a subclass-superclass hierarchy. A class hierarchy is usually an IS-A hierarchy (see Figure 4.16 and Figure 4.17): an instance of a subclass is an instance of a superclass. If a class is regarded as a set of elements, then a subclass is a subset. For example: Apple is a subclass of fruit (every apple is a fruit), an overseas account is a subclass of a bank account (every saving account is a bank account)

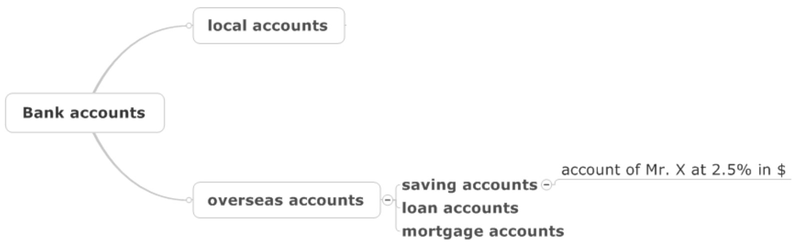

Figure 4.16 A sample of a hierarchy [215]

The following activity is to *define properties.* Properties, in a class definition, describe attributes of the class and relations to other classes (e.g. each account will have an assigned customer, currency type, opening date, interest rate). There are different types of properties: intrinsic (e.g. currency type, opening date), extrinsic (e.g. assigned customers), relations to other objects (e.g. assigned customers – customers' details). A subclass inherits all the properties from the superclass (If a bank account has an opening date and currency type, an overseas account has also an opening date and currency type). Classes and properties usually have documentation. They are described in natural language; listed with domain assumptions, synonyms relevant to the class definition [215].

Some properties may require limitations. Thus, *define constraints* is another activity in the ontology engineering process. Property constraints describe or limit the set of possible values for a property (for example, the name of a customer is a string; the interest rate is integer, the saving account has exactly one customer). There are four common constraints of a property: cardinality – the number of values a property has; value type – the type of values a property has (e.g. string, number, boolean); minimum and maximum value – a range of values for a numeric property; default value – the value a property has unless explicitly specified otherwise.

Second last activtiy of the ontology engineering process is to *create an instance of a class*. The individuals in the class extension are called the *instances* of the class. The class becomes a direct type of the instance. The role of the individuals is to give examples of use of the class. Researchers need to assign property values for the instance class (e.g. Mr X's account - Figure 4.16). Properties values should conform to the facet constraints, but knowledge-acquisition tools often check that (e.g. protégé frames). Once all classes are identified and described, an UML class diagram [127] can be used to visualize the ontology (e.g. Figure 4.17). The visual is to help understand and better comprehend the domain of interest.

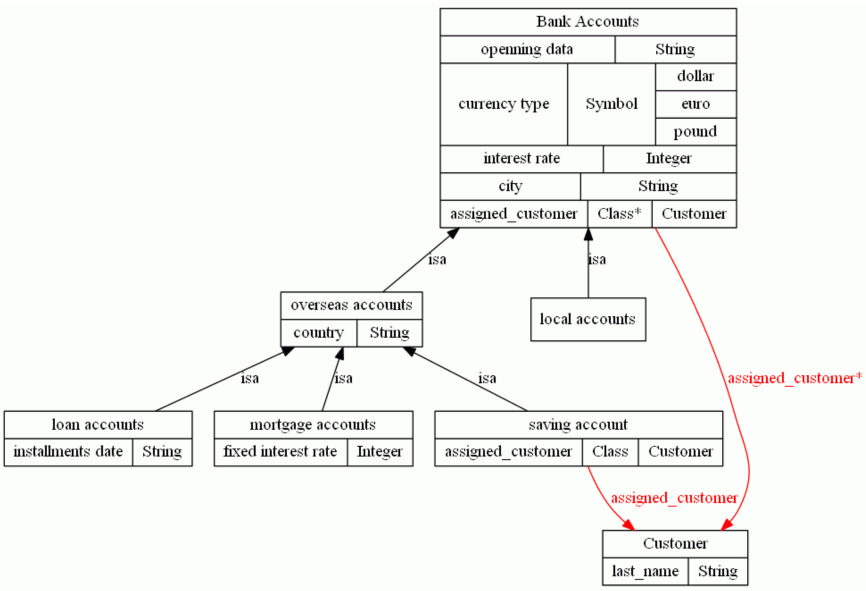

Figure 4.17 An Example of UML diagram Bank Accounts Ontology [215]

Table 4.14 summarizes the activity discussed above in relation to its layers.

Table 4.14 The Overview of the Construct Ontology activity

Construct Ontology	Construct	Model	Method
Literature source	Enumerate terms, define classes, properties, constraints, instances	Figure 4.15	Identifying key terms and definitions of activities, defining a class for each term and relations between them using properties, Additional constraints can be applied, creating sample instances of the classes. Generating class diagram for visualization purposes.
Collaboration source	Generate class diagram		
Evaluation	It was applied to the first experimental design (section 5.4.2) and its outcome was also observed during the second experimental design (section 5.4.3) and three case studies (sections 5.5.1, 5.5.2 and 5.5.3). It was discovered that the ontology structures not only the information gained but also it gives an overview of the activities for the researched business process model. Properties of the found activities point out to their flow and depict the high level of the business process model. It provides the hierarchy of activities.		

Next phase following the process-oriented reference model Figure 4.14 is to use this structured knowledge base to construct the business process model of interest. The following section presents and justifies business process modelling techniques that can be applied to form the knowledge base into a business process model artefact.

4.4.2 Construct a Process Model

In the previous section, information gathered either during literature review or collaboration with practitioners has been structured into a knowledge base. The relationships between terms and attributes in the knowledge base serve as a source to construct the business process model artefact of interest. The construction of the business process model investigated is carried out using business process modelling techniques.

The section 3.5.1 outlined that BPMN provides the notation to represent a business process model artefact. However, it does not provide guidelines on how to transform process related information (for example a knowledge base) to a business process model. The construct layer for this activity was defined with the following components: create context diagram, process level 1, decompositions of level 1. The first component was identified in literature review, the last two were provided by practitioners during focus groups and interviews. The Figure 4.18 below illustrates the model layer of these components

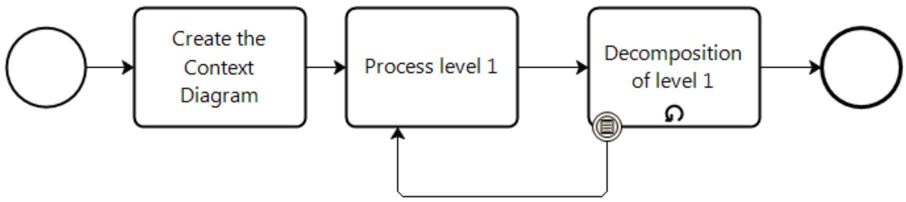

Figure 4.18 Construct a Process Model - model layer

The process-oriented reference model refers and employs top-down expansion approach which starts with an overall picture of the business process and continues by analysing each of the top process activities of interest [216]. This analysis can be carried out to a precise level of detail required. However, the number of required levels becomes clearer during construction of the process model. Each level is represented using BPMN. The top-down approach in the process-oriented reference model comprises one or more diagrams. Initially *a context diagram* is drawn, which is a simple representation of the business environment in which the investigated business process model resides. This is followed by *a level 1 diagram* which identifies the main business process activities at a high level and any of its sub-processes can then be analysed further - giving rise to a corresponding level 2 process diagram. Analysis of the process activities can then continue – through level 3, 4 and so on. However, literature indicates that most analysis will stop at level 2 and it is very unusual to go beyond a level 3 diagram [216].

The context diagram is drawn first and used to clarify and outline the environment in which the business process under investigation operates. The process is connected to external entities by data objects and message flows. It shows the interfaces between the business process under investigation and the external entities with which it communicates. Figure 4.19 gives an example of such diagram. A context diagram serves to focus attention on the process boundary and can help in clarifying the precise scope of the analysis.

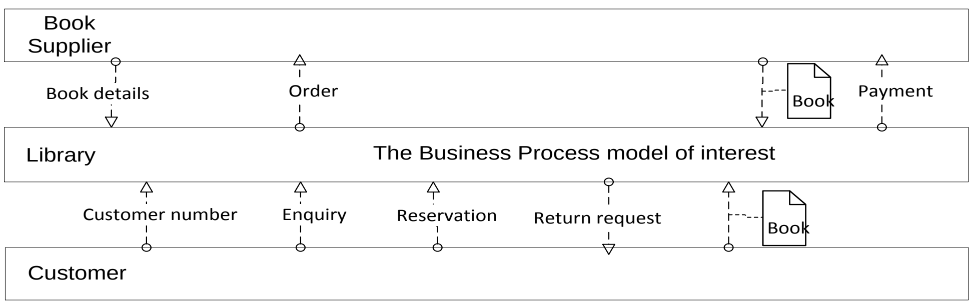

Figure 4.19 A Context Diagram with BPMN

The communication involving external entities (e.g. book supplier, customer) are only included where they interact with the process model. For example, an external entity would communicate with various other entities, which are remote from the process and so this is not included on the context diagram.

Process diagram level 1 shows the main process activities under investigation. Similarly to the context diagram, any business process under investigation should be represented by only one level 1 diagram. There is no formula that can be applied in deciding what is, and what is not, a level 1 process [216]. The level 1 should describe only the main activities of the process, and the temptation of including lower level processes on at this stage should be avoided. As a general rule no business process should contain more than 12 process activities (e.g. tasks, sub-processes) [216]. Figure 4.20 gives an example of a level 1 process.

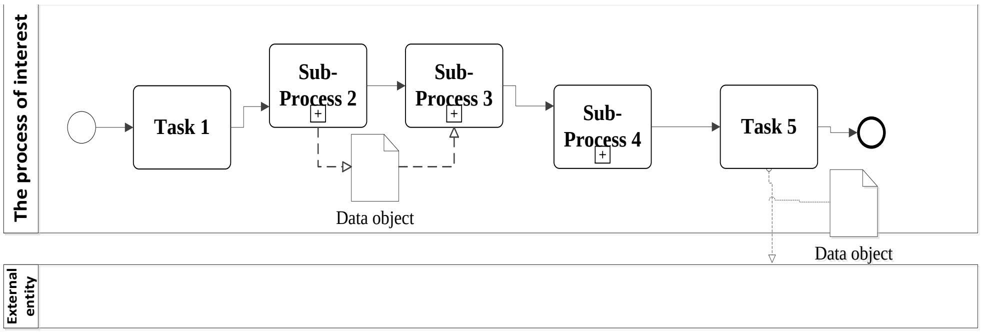

Figure 4.20 Business Process Level1

The level 1 diagram is surrounded by Pool that represents the boundaries of the system. Because the level 1 diagram depicts the whole of the business process model under investigation, it can be difficult to know where to start. There are three different methods, which provide a practical way to start drawing [217] :

- Data Object Analysis is used if the process consists largely of the flow of goods, as this approach concentrates on following the flow of physical objects [216] .
- Lane Analysis starts from the main Lanes that exist within the domain, rather than the goods or information that is flowing around the process [217].
- Message Flow Analysis is used if the part of the process under investigation consists principally of flows of information in the form of input and output [218]

Whilst there can only be one context and one level 1 diagram for a given process, these normally give rise to numerous lower level diagrams. Each process within a given process diagram may be a subject to further analysis. This involves identifying the lower level processes that together constitute the business process of interest. As a process diagram is decomposed, each process activity, unless it is a task activity, becomes a boundary for the next, lower level, process. There are a number of analyses that help to determine when to stop the top-down expansion [217]:

- A process has a single input flow or a single output flow then it should be apparent that there is little point in analysing it any further.
- A process is accurately described by a single active verb with a singular object; this indicates that the analysis has been carried out to a sufficiently low level.
- If nothing useful will be gained by further decomposition of a process.

Where many different levels of a process are modelled, there is a need of structural guidelines for arranging the layout of the processes in order to manage their comprehensibility. The comprehensibility of the layout concerns the graphical arrangement of the information objects, and, therefore, supports the rationality of a model. Rules are demanded for the arrangement and interrelation description of information objects, e.g., the placing of entity types in a data model from left to right representing their importance [219]. Table 4.15 illustrates criteria for clarity in modelling.

Table 4.15 Layout Design [220]

Criteria	**Objectives/Goals**
Angle	Angles between edges should not be too small.
Area	Minimize the area occupied by the drawing.
Balance	Balance the diagram with respect to the axis.
Convex	Minimize the number of bends along edges.
Crossing	Maximize the number of faces drawn as convex polygons.
Degree	Place nodes with high degree in the centre of the drawing.
DIM	Minimize differences among nodes' dimension.
Length	Minimize the global length of the edges.
Maxcon	Minimize length of the longest edge.
Symmetry	Have symmetry of sons in hierarchies.
Uniden	Have uniform density of nodes in the drawing.
Vert	Have verticality of hierarchical structures.

In addition, there is a variety of techniques to show how a process diagram can be clarified and easily read by users. For example, where a data object is being updated, only the data flow representing the update needs to be shown. The fact that the information must first be retrieved does not need to be shown. Only the most important reports, enquiries, are needed to be on the diagram. Communications that are of less significance can, if necessary, be detailed in support documentation [217]. Documentation is discussed in the section 4.4.4. Table 4.16 summarizes the activity discussed above in relation to its layers.

Table 4.16 The Overview of the Construct a Process Model activity

Construct a Process Model	Construct	Model	Method
Literature source	Context diagram	Figure 4.18	First a context of the identified activities is identified, then level 1 gives the high level overview of the activities involved in relation to the business environment. Decomposition of the level one goes till each activity does not need further decomposition.
Collaboration source	Process level 1, decomposition of level 1		
Evaluation	It was applied to the first experimental design (section 5.4.2) and three case studies (sections 5.5.1, 5.5.2 and 5.5.3). Its outcome was also observed during the second experimental design (section 5.4.3) It was discovered that top-down expansion gives a quick overview of the shape of the process and stakeholders involved can benefit from seeing shape of the final outcome. Decomposition of the process model up to the level 4 was efficient in all cases. With each additional layer, a revision of a layer above usually occurred.		

Once business process models based on the information retrieved from literature review and collaboration with practitioners are constructed, they are analysed and synthesized into one business process model that answer the research problem stated in the research scope. The goal of the process-oriented reference model is to produce a consolidated business process model that takes academia and practitioners' expertise into account. The following section discusses how to synthesise individually constructed business processes models into one, the consolidated business process model artefact.

4.4.3 Synthesise Processes

Synthesising business process models involves collating and summarising models constructed with the knowledge gathered from literature review and collaboration with practitioners. At this phase of the design research, there should be two or more business process models, one from literature review and at least one from the collaboration with practitioners. Otherwise, the synthesis phase is skipped and the research continues on the documentation activity for one business process model. The synthesis aims at the semantic comparison of two or more models, i.e., the content of models shall be compared regarding its correspondence and similarity. The synthesis is carried out on the levels of ontology set (i.e. the constructed knowledge base for each business process model) and then a business process model. A comparison on these levels is only possible, if different languages and grammars, respectively, are compatible [219]. That was the main reason of introducing the same modelling techniques for constructing business processes based on literature review and collaboration with practitioners, as discussed in the section 4.1.1 and shown on the Figure 4.2. The comparison of the semantics in the ontology sets is much more difficult, since the number of objects to be compared is much higher and the elements used obey higher standards than the semantic elements in the business process model. Moreover, a comparison of ontology sets provides the knowledge base consolidated for the consolidated business process model. Having the knowledge base consolidated comparison of business process models and composition of the consolidated process takes place. Different business process models may use terms and concepts with subtly different meanings, thus the knowledge base consolidated (ontology sets combined) is to integrate models comprising natural language results and conclusions. The consolidated business process is obtained by tabulating in a manner consistent with the research problem and highlighting similarities and differences between models. Thus first, techniques are introduced to synthesise the knowledge bases (ontology sets) of single business process models, and then the synthesis of business process models that is supported with the ontology synthesized.

Synthesis of Ontology

Ontology carries information which enriches the description of and helps build the business process models within the process-oriented reference model. Ontology is a shared specification; the same ontologies can be used for the annotation of multiple data sources. This, however, does not solve the integration problem completely, because it cannot be expected that all authors in the literature and practitioners will ever agree on using one common terminology or ontology [221]. It can be expected that many different ontologies will appear while researching and, in order to enable the consolidated ontology, differences between these ontologies have to be reconciled.

The construct layer for this activity was defined with the following components: alignment, merging, mapping. The first two components were identified in literature review, the last one was provided by practitioners during focus groups and interviews. The Figure 4.21 below illustrates the model layer of these components

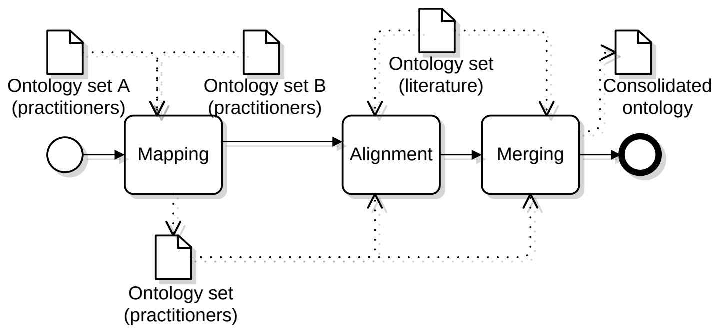

Figure 4.21 Synthesis of Ontology – model layer

In the process-oriented reference model, mapping occurs for ontologies coming from practitioners to specify and determine overlaps between them. It is mostly concerned with the representation of correspondences between ontologies. The correspondences between different entities of two ontologies are typically expressed using some axioms formulated in a specific mapping language [222], for example MAFRA [223] or C-OWL [224]. They constitute the vocabulary for the representation of mappings. Then, following the assumption, that ontology of the domain constructed from literature review is the existing ontology of the domain, the researchers align it to the mapped ontology from practitioners. It is generally described as the application of the match operator [225]. The input of the operator is a number of ontology and the output is a specification of the correspondences between the ontologies [222]. There are many different algorithms which implement the match operator. They can be classified along two dimensions: element-level and structure-level matching. An element-level matcher compares properties of the particular concept or relation, such as the name, and uses these to find similarities (e.g. PROMPT [226]). A structure level matcher compares the concept hierarchy of the ontologies to find similarities (e.g., Anchor-PROMPT [227]). Finally, the ontology consolidated that is a merged version of these two perspectives is created. It concerns creating the union of ontologies. It unifies and in general replaces the original source ontologies. A prominent example of this approach is PROMPT [226], which is an algorithm and a tool for interactively merging ontologies Figure 4.21 shows how these three techniques correspond with reaching for the ontology consolidated to build the consolidated business process model. Figure 4.22 outlines the correspondences between ontologies.

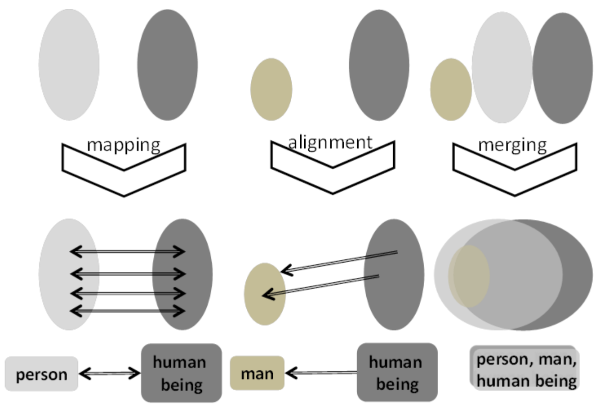

Figure 4.22 Correspondence between ontologies

Table 4.17 summarizes the activity discussed above in relation to its layers.

Table 4.17 The Overview of the Synthesis of Ontology activity

Synthesis of Ontology	Construct	Model	Method
Literature source	alignment, merging	Figure 4.21	Map ontologies from all collaboration focus groups, align it to the ontology from literature and then merge it into one.
Collaboration source	mapping		
Evaluation	It was applied to the first experimental design (section 5.4.2) and three case studies (sections 5.5.1, 5.5.2 and 5.5.3). Its outcome was also observed during the second experimental design (section 5.4.3). It was discovered that mapping and aligning ontologies mainly required identifying corresponding activities whereas merging choosing the leading one for the business area. The selection was done based on the thoroughness of descriptions and corresponding sources, e.g. number of occurrences		

Synthesis of Business Process Models

Having the ontology consolidated synthesis of business process models and composition of the consolidated business process is taking place. Different business process models may use terms and concepts with subtly different meanings, thus the consolidated ontology from the previous section integrated terms used in the business process models comprising natural language results and conclusions. Hence, the consolidated ontology serves as a knowledge base and point of reference to all business process models being synthesised. The construct layer for this activity was defined with the following components: concept tables, examining context of models, revising concept tables, ordering interpretation, synthesising models, and merged ontology. The first four components were identified in literature review, the last two were provided by practitioners during focus groups and interviews. Figure 4.23 summarizes phases involved in the synthesis of business process models.

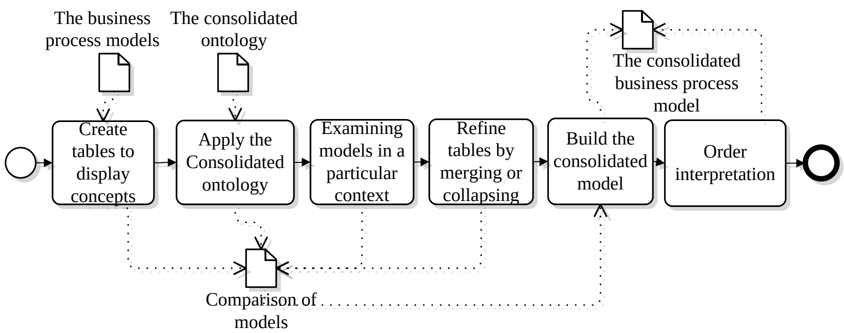

Figure 4.23 Synthesis of Business Process Models – model layer

The consolidated business process model can be obtained by tabulating in a manner consistent with the scope of the business process model investigated. Tables should be structured to highlight similarities, differences between models, and lead to one common model. Design science researchers can achieve this synthesis by applying meta-ethnography technique. It puts together written interpretive accounts [228] where quantitative integration would not be appropriate, as in this case.

Application of the meta-ethnography technique, following Noblit [228], starts from *creating a list of themes or tables* to display activities across all models. It's a good practice to reduce the themes into relevant categories as progressing. It implies comparing the categories and activities in one account with the categories and activities in others. The individual business process models should be sufficiently similar in their focus (due to the detailed initial research scope and the same modelling techniques) to allow reciprocal translation. The reciprocal translation aims at *applying the consolidated ontology* to all business process models and outlining key categories and activities. The consolidated ontology enables the same terminology to each model which in fact puts on ease comparing the categories and activities of a model 1 with a model 2, and the synthesis of these two models with a model 3, and so on, beginning from the categories created above, but keeping an open mind for emerging ones. This *examination of models in their context* is held in the light of the top-down expansion as comparing business process models starts from their top levels. For each business process model, a context related to a given category is examined in detail – for example, a certain output of a task. As the synthesis progresses, the initial broad categories of themes are gradually *refined by merging and collapsing*. At this stage, the refutational synthesis occurs as well. Contradictions between activities in models are explored and explained in order to get them properly categorized. This all filters and outlines an order of activities to *build the consolidated business processes model* artefact using BPMN. While this approach is pragmatic, and assisted in the synthesis of many disparate models, it is possible that this prior categorizing had some effect on the results of the synthesis, and may have constrained the emergence of new categories [229].

As the context is important in the meta-ethnography synthesis, and lends credibility and weight to certain business process models, the intention of the synthesis is to retain the rich context of the data. Thus, the synthesis should explore systematically the influence of various contextual factors and perspectives. However, this might be difficult due to poor reporting of contextual information in some cases of collaboration with practitioners, possibly caused by time limits. The problem of how to retain the rich context of the models when conducting a synthesis is therefore complicated by the failure of literature authors or practitioners to provide adequate descriptions of context or of the impact of context on findings. Some syntheses have attempted to circumvent this problem by first examining only models undertaken in a particular context.

The meta-ethnography technique can proceed from reciprocal translation to a higher *order interpretation* which distils the translations into more than the models alone imply – a "line of argument" synthesis. Literature indicated that researchers arrive at synthesised translations in a variety of ways [229]. There appears to be a general acceptance that the synthesis technique cannot be reduced to mechanistic tasks [230], and may, in practice, be difficult to replicate. Differences in synthesis approaches may be due to differences in the extent to which included models report second order interpretations and in the number of models included in the synthesis. As the process of “line of argument” synthesis in meta-ethnography is not clearly delineated, this approach is based on a method of synthesis based on reading of a number of existing reviews [229]. Having the consolidated business process model from the reciprocal translation analysis, a design science researcher lists the translated themes and subthemes in a table, puts together with secondary themes derived from other business process models. These interpretations of models are then discussed in order to produce the consolidated order interpretation, which is a 'line-of-argument' synthesis. In case of two researchers, synthesising results in this manner prove rather difficult, as the interpretations of different researchers may vary widely. Inevitably, compromises need to be made. This highlights the similarity of qualitative synthesis with primary qualitative research, in terms of the inherent subjectivity of interpretation [229]. Table 4.18 summarizes the activity discussed above in relation to its layers.

Table 4.18 The Overview of the Synthesis of Business Process Models activity

<table>
<tr><th>Synthesis Models</th><th>Construct</th><th>Model</th><th>Method</th></tr>
<tr><td>Literature source</td><td>Concept tables, examining context of models, revising concept tables, ordering interpretation</td><td rowspan="2">Figure 4.23</td><td rowspan="2">Meta-ethnography approach requires comparing activities from models in a tabular fashion, going from the high level towards the decomposed levels, and synthesising by retaining the rich context of activities. This is supported with the consolidated ontology. The order of the synthesised process is then determined.</td></tr>
<tr><td>Collaboration source</td><td>synthesising models, merged ontology</td></tr>
<tr><td>Evaluation</td><td colspan="3">It was applied to the first experimental design (section 5.4.2) and three case studies (sections 5.5.1, 5.5.2 and 5.5.3). Its outcome was also observed during the second experimental design (section 5.4.3). It was discovered that synthesising the business process models cannot be mechanical, and requires synthesizing activities in relation to their business context. Thanks to the consolidated ontology the selection of most appropriate terms and decryption for activities was provided. The challenging part was to link activities, coming from different models, in the relevant business context.</td></tr>
</table>

The final phase of the information modelling phase of the process-oriented reference model (Figure 4.14) is to systematically document the consolidated business process model and its order interpretation. This is presented in the following section.

4.4.4 Document the Process

The final activity in the process-oriented reference model is to document the consolidated business process model of the research circulating the results to potentially interested parties, usually the ones that stated research objectives and problem. This could include the research supervisor, practitioners involved in collaboration or executors of the following design science phase - design practice (Figure 2.6). The structure and contents of the business process model description may need adjustments to the specification of a domain and requirements stated in the research objectives. The construct layer for this activity was defined with the following components: a scope statement, roles involved, process activities, process exception, an applicability matrix, decision matrix, impacts on the business. The first four components were identified in literature [231], the last three were provided by practitioners during focus groups and interviews. The Figure 4.24 below illustrates the model layer of these components

Figure 4.24 Document the Process - model layer

A scope statement of the consolidated business process model commences the business process model documentation. It can be supported with the research initial scope from section 4.2.1. The goal of the part is to state what the consolidated business process model is trying to solve, why it needs to exist, and who the end user is. If the scope statement cannot fit within a few paragraphs, then perhaps the scope is too large. It should be clear, yet as all-encompassing as possible. For example, it could have a scope statement such as "This document covers the following business process and sub-processes:" with bullets listing them. Each bullet should have a short description that captures the stakeholders' desire for a solution as well as their needs. They should be then elaborated in individual paragraphs. The goal is to be sure that as readers begin reviewing the description they understand what the business process model covers [231].

The applicability matrix is to allow readers to see the scope stated in the previous section and parties responsible for the processes. Having this information at the beginning of the business process documentation gives readers the ability to quickly see who handles certain pieces of the process and what those pieces are. The matrix diagram helps visualize the information, however, it can be provided in a text format as well. The exact areas of information in an applicability matrix may differ from process model to process model but it may include some of the following: business unit, customer facing unit, overall process, and people responsible for the process.

The following section of the documentation cover *impacts of the business process* on the business. In most business cases, it affects a product line and/or services of the business. Its goal is to give readers a clear understanding of which product lines and services are included in the processes. An example might be "This process includes the following product lines:" with a bulleted list for easy reading. Description of them in a few paragraphs would make clearer to the reader how the process impacts and what function serves.

Next section covers *roles and/or positions* responsible for ensuring the business process flows properly and effectively. This allows discovering if there are uncover areas in the process for which no one claims responsibility. The responsibilities should start with the roles assigned for deploying the process at its most base level and work through anyone else who approves all or part of the process.

In the *process activities* section, a detailed description of each activity of the process is provided. This is supported with the consolidated ontology and the consolidated business process model diagram in BPMN. Mainly it asks for an explanation of the activities of the business process that has been created. Each activity clearly states where the input data comes from, and where the output will be sent. Readers can find how to execute each activity and which tools are there to support. For some, simple paragraphs will be sufficient, for others it may mean the inclusion of a chart or graphic to show how the activities are linked.

The *process exception* section of documentation deals with the elements of the business process model, which can offer an alternative set of activities that were not included in the consolidated business process model. During the synthesise some activities could have been put aside as an alternative approach. Here is the opportunity to introduce these alternative activities and circumstances in which their application should be preferable. The exception procedures are presented in the same layout as the consolidated ones. It is helpful to indicate the role of exception process facilitator [231]; however, this can be handled by any other role that seems appropriate. This section provides a graphic showing how the exception change process flows. Including graphic representations alongside a text is always appreciated by readers.

The final section of the business process model documentation is to include a *decision matrix*. It shows readers exactly who can actually make decisions and the types of decisions that can be made. Roles or relevant positions of the process need to be established for a decision matrix. These roles are used to underline “who has the ability to approve a decision; who must review a proposed decision; who can approve a proposed or final decision; and who must be consulted with before the decision is finalized” [232] . Table 4.19 summarizes the activity discussed above in relation to its layers.

Table 4.19 The Overview of the Document the Process activity

Document the Process	Construct	Model	Method
Literature source	a scope statement, roles involved, process activities, process exception	Figure 4.24	Introducing the scope of the process, its business context, roles required to carry it out and description of each activity are the main section in documentation. Alternative process paths and decision matrix to define them are to adapt the process to changing business scenarios.
Collaboration source	an applicability matrix, decision matrix, impacts on the business		
Evaluation	It was applied to the first experimental design (section 5.4.2) and three case studies (sections 5.5.1 5.5.2 and 5.5.3). Its outcome was also observed during the second experimental design (section 5.4.3). It was discovered that in addition to the process description supported with the found materials document, the process scope and applicability matrix added transparency to the business process model. This means, stakeholders pointed to these sections as the ones that helped them understand the process model and its execution path.		

Documentation will typically be considered good if it fulfils the research objectives in a meaningful way. If some aspects of the business process model are not justified, then it is probably worth re-evaluating. Moreover, it is important to document any benefits that result from the model. This is to let others who read the document to understand what value they can gain. Likewise, any associated risks must be documented. A well written document minimizes unexpected complications by addressing them before moving to the design practice phase of design science research (Figure 2.6). Finally, this document provides a common vocabulary for the investigated business process model.

4.5 Summary

This chapter outlined the components and sequence of activities for the design and construction of business process model artefacts. Adopting a conceptual framework derived from design science research approach, the process-oriented reference model was built. Then, the following sections provided characteristics of its key elements and phases. The process-oriented reference model is a combination of two processes (literature review and collaboration with practitioners) which use the same modelling techniques to present their findings. These findings concentrate on constructing business process models, which eventually are synthesized to provide a consolidated business process model that provides a solution to the design science research in question at the level of meta-design phase of design science research (Figure 2.6)

This chapter covered the construction theme of this research. In the following chapter 5, the focus is put on the quality and impact themes which refer to the evaluation of the reference model. Evaluation is carried out following four evaluation perspectives for reference models [24] and using experimental designs and case studies methods with the support of questionnaires to collect and analyse data. The following chapter ends with a discussion regarding activities that the reference model can contribute to broader types of design science artefacts. These activities constitute the general activities of the meta-design phase in design science research methodology.

5 The Reference Model Evaluation and Discussion

5.1 Introduction

The chapter four outlined the design and construction of the research artefact; the process-oriented reference model. It synthesised process oriented research practices that guide design science researchers throughout the meta-design phase of the design science research process in order to build business process model artefacts. The genesis of the research is the lack of specificity of general activities for the meta-design phase of design science research methodology. From evaluating the reference model in a complex design science research environment, general meta-design activities are inferred. Hence, this chapter focuses on evaluation of the reference model in the line of the research design, as described in the section 3.5. It presents and discusses the general activities inferred that apply not only to business process models but also to other types of design science artefacts.

Evaluation delivers evidence that a research artefact achieve the purpose for which it was designed. Without evaluation, outcomes are unconfirmed declarations that the artefact meets its purpose (e.g. be useful for solving a problem or making some improvement). A design science research artefact is assessed against criteria of value or utility – does it work? [53] The essential aim is establish if the artefact works in a real situation, its effectiveness. [185]. Evaluating artefacts can be perceived through the information system design theories or design principles, which formalizes the knowledge of the design science artefact [59]. Value of an artefact is a complex deliverable. It may depend on many different attributes of the artefact or desired outcomes of the use of the artefact. Researchers stated that "artefact can be evaluated in terms of functionality, completeness, consistency, accuracy, performance, reliability, usability, fit with the organization, and other relevant quality attributes” [8]. Thus, each evaluation is quite specific to the artefact, its purpose, and the purpose of the evaluation [184].

There have been several attempts to guide the evaluation of a reference model type artefact. They all stressed the necessity to use a multi-perspective approach for conceptualizing the notion of a model [233,234]. These perspectives are often inspired by linguistic categories (syntax, semantics and pragmatics), users’ perceptions or relationship of the model to the reality [235,156]. The Multi-Perspective Framework for Evaluation Reference Models [24] that is applied in this research made eclectic use of the work from the field. It stresses the multi-perspective approach and fosters differentiated and balanced judgement.

The framework comprises four main perspectives which are structured in a number of specific facets. They may seem independent but some overlapping and relations can be observed. Their main differentiation is driven by analytical reasons. The *economic* perspective takes into considerations criteria that are relevant for assessing costs and benefits related to the use of reference models. It also considers protection of investment, possible effects on information quality and competitiveness. The *epistemological* perspective is aimed at evaluating reference models as the results of scientific research. For this purpose, it focuses on criteria for evaluating scientific theories as they are discussed in philosophy of science. In this research it reflects the design theory that the reference model constitutes. The *deployment* perspective takes into account criteria that are relevant for those who work with the reference model. As the objectives for the reference model indicate the stress on the representational information quality. This covers concise representation, consistency, ease of understanding, and interpretability as discussed in the section 2.5. A reference model is an artefact that has been designed for a certain purpose. Thus, its evaluation is executed in relevant circumstances. Finally, the last *engineering* perspective is focused on evaluating a reference model as a design artefact that has to satisfy a specification— to build a business process model artefact in design science research in accordance with research objectives.

This chapter examines the reference model accordingly to the perspectives above-mentioned. It summarises how this research work meets research objectives. Finally, it discusses which general activities can be inferred from the reference model to address their lack in the meta-design phase of design science research methodology.

5.2 Economic

The usage of a reference model should make development more efficient. Hence, researchers postulated the economic perspective of reference models [236]. In the context of the process-oriented reference model the efficiency is focused on building business process model artefacts in design science research. This evaluation perspective assesses from both the business management and national economic standpoint, e.g. costs and benefits analysis or investment theory. This perspective leads to little concrete results because the assessment is deficient (e.g. priori benefits of a reference model can only be estimated and not exactly determined).

The construction and the use of reference models are perceived through economic facets. In this perspective, it is taken into account a point of view of the process-oriented reference model user rather than the reference model constructor. It distinguishes three types of the model users who depend on the purpose for which they need the model [24]. First type approaches the reference model as a foundation of standards. Design science researcher can use the model to create business process model artefacts that inhabit the standards and their relationships to one another. By having standards, the works of researchers, who need to create deign science artefacts that behave accordingly to the standards, is met. Software can be written that follows these standards and researchers can make a use of the software to produce standardized artefacts. Standards can make use of design patterns that support key qualities of software artefacts, such as the ability to carry on research in an inexpensive way. For another user type, the reference model serves as a guideline for development of business process models artefacts. Referring to the model, researchers can break down a large business process research problem into smaller problems that can be understood, tackled, and refined. Researchers who are new to design science research can learn how to go through each phase, and can focus on the problems that they are being asked to solve, while trusting that other areas are well understood and rigorously constructed. The trust in the reference model enables the researchers focus on their work. The reference model enhances communication between researchers and stakeholders involved. It provides an explicit recognition of concepts with which many stakeholders are familiar, but when they use them in particular research context cause confusion. Thus, the reference model defines how these concepts differ from and relate to one another. A third group of users are primarily to create clear roles and responsibilities for conducting design science research. By applying the reference model, a research supervisor can dedicate specific individuals or teams to be responsible for solving a problem that concerns a specific set of entities or process activities. For example, one group of researchers can be assigned to the literature review activities, another to collaboration, and some others to the process synthesis. This enables a senior researcher or a research supervisor to hold each of their team members responsible for producing meaningful results. In most cases, different reference model users are combined, for instance design science research follows the reference model to develop a set of business process model artefacts complying with the same business process standards. The following discussion of economic aspects takes into account these three types of users together for each category suggested by the Multi-Perspective Framework for Evaluation Reference Models [24]: costs, benefits and protection of investment.

Table 5.1 comprises criteria that serve to guide the estimation and evaluation of costs to be expected with the use of the reference model. The criteria depend on features of a model that are the subject of other perspectives or intention of application of the model. The term costs do not refer implicitly to monetary values as unit measures.

Table 5.1 Costs of the Reference Model

Criteria	Description	Process Oriented Reference Model
Acquisition	Cost of purchasing, Licensing model	DCU intellectual property agreement will be required. The exact price is estimated on individual basis.
Training	Familiarity of design science researchers with modelling language, terminology	BPMN – 3 days OWL-Frames - 2 days Facilitating Focus Groups – 2 days
Tools	Cost of integrating research tools with existing software and research environment	Bizagi Modeller - free Protégé 3.4.8 - free Web-browser – free Group Support Systems – mostly freeware
Integration	Integration with existing models, amount of integration required, compatibility of modelling concepts	Business process artefacts as well as the model itself support: BPMN – standard for Business Process Modelling XML – data format OWL – knowledge representation
Conceptual support	Concepts that support adaptation in a safe and convenient way	It is based on emerging design science research methodology, thus it supports research following design science paradigm. Applying it to a different research paradigm may become risky and expensive

The use of the reference model promises a number of benefits. Underlying the overall potential benefit in a number of categories can contribute to an evaluation that supports a comprehensive comparison with alternatives—such as conducting a design science research without the reference model. Table 5.2 presents categories for this purpose.

Table 5.2 Benefits of the Reference Model

Criteria	Description	The Process Oriented Reference Model
Development	Improvement of productivity Improvement of artefact quality Skills of researchers Willingness to use reference model	By detailed operational activities the model enhances research transparency and traceability. Statistically significant improvement was observed in representational information quality of its artefacts (see section 5.4). The model can be used by both senior and junior design science researches.
Business Management	Increased efficiency of affected business processes. Support for specific decision scenarios. Improved customer-orientation	It supports business process oriented research encompassing academia and best practices. It is most suitable for development of business process model artefacts. It enhances a research process.
Openness	Compatibility to relevant standards. Integration with further reference models	It is compatible with business process modelling standards such as BPMN. It supports a textual data format with strong support via Unicode and sharing knowledge base through OWL.
Knowledge Management	Contributes to dissemination of relevant knowledge Contributes to cross-organisational exchange of knowledge	It engages practitioners to the research by creating the opportunity to share best practises and contribute to the research at the same time. It incorporates relevant, external knowledge using an unified terminology By its structure, it enables researchers to keep track of the research progress.
Coordination	Helps to overcome communication barriers within stakeholders Fosters communication with external partners	The collaboration with practitioners part of the reference model as well as the design research process foster and coordinate communication with people involved.

Having considered that using a reference model can cause a substantial investment, in Table 5.3 are presented criteria that examine these concerns [24]

Table 5.3 Protection of Investment in the Process Oriented Reference Model

Criteria	Description	The Process Oriented Reference Model
Commitment	Number of vendors and service providers that support the model. Standardisation of modelling language	There is a variety of vendors that support functionality of the reference model (e.g. Table 4.10) free of charge. The embedded standards of BPMN and OWL enable use of software desired by users.
Technological change	Independent from a particular technology. Supports technologies that can be expected in near future.	The technological trend is to provide users with capability of understanding their internal and external processes with a graphical notation and give them the ability to communicate these processes in a standard manner. The evolvement takes into account standards provided in the reference model.

The reference model serves as a medium to foster communication between stakeholders with different professional backgrounds and design science researchers. At the same time, it represents knowledge about a design science research process. Finally, it provides additional support for coordination and knowledge management because it enhances the number of people and institutions to communicate with, and it may incorporate knowledge from external sources that adds to the research knowledge base.

5.3 Epistemology

Epistemology perspective enriches the evaluation of reference models with epistemological considerations [24]. This is to evaluate a reference model as results of scientific research. The reference model artefact is a result of design science research. Researchers distinguish four interrelated epistemological facets: the evaluation of theories, general principles of scientific research, critical reflection of human judgement and reconstruction of scientific progress [24]. Reference models reveal similarities to scientific theories. Like theories, they provide representations not just of a single instance (e.g. a business process model of data migration to the cloud) but of an entire class. Moreover, they should be viewed as contributions to the body of knowledge within a certain domain of interest. In the context of the reference model the domain is design science methodology for the purpose of business process model artefacts and the meta-design phase.

As design science research aims at solving problems [8], the central focus of design science is to support the specification of future artefacts, e.g. new business process models. Thus, design is a set of postulates which ultimately can be proven only by construction of the artefact it describes. The construction of the artefacts of the business process reference model is presented in the next sections 5.4 and 5.5. The feasibility of a design can, however, be supported by "scientific theory to the extent that the design embodies principles of the theory" [32]. Hence, formulating design specifications is observed as the same process of formulating theories. Theories in design science are of prescriptive nature comparing to the explanatory and predictive nature of theories in natural science, as discussed in the section 2.3. As design theories aim at providing guideline on how to solve a specific problem. They cause an artefact of a certain type to come into being [60]. Design theories prescribe certain design principles that will lead to applications, which are more effective [237].

Drawing upon the discussion above and relevant literature review in section 2.3.1 this research employed seven components of an information systems design theory for the epistemological evaluation of the reference model artefact. The seventh component of justificatory provides an explanation of why the design works. These components allow design science researchers (1) to identify what theory is composed of in general and (2) to analyse the components of their own theory and the theory of others. Table 5.4 outlines a design theory of the reference model artefact as a result of design science research.

Table 5.4 Design Theory for Business Process Model Artefacts

Components	Description	The Process Oriented Reference Model
Theory Component (Components Common to All Theory)		
Means of representation	The theory is represented physically in some way: in words, mathematical terms, symbolic logic, diagrams	text format, screenshots, and diagrams
Constructs	These refer to the phenomena of interest in the theory.	A systematic approach to build business process model artefacts within design science paradigm
Statements of relationship	These show relationships among the constructs. The nature of the relationship specified depends on the purpose of the theory.	A business process model is built on two combined processes - literature review and collaboration with practitioners that used the same modelling techniques.
Scope	The scope is specified by the degree of generality of the statements of relationships and boundaries showing the limits of generalizations.	It provides operational activities for design science research aiming at business process models artefacts
Theory Component (Components Contingent on Theory Purpose)		
Causal explanations	The theory gives statements of relationships among phenomena that show causal reasoning.	A systematic literature review and collaboration with practitioners enables mutually beneficial exchange of knowledge and resources that enhances a research artefact
Testable propositions	Statements of relationships between constructs are stated in such a form that they can be tested empirically.	Operational activities in design science methodology assist researchers in producing business process model artefacts of better representational information quality
Prescriptive statements	They specify how one can achieve something in practice (e.g. construct an artefact or develop a strategy).	The reference model is a set of activities and principles for designing business process model artefacts

In natural science, a theory focuses on describing the world the way it is. Truth is its key criterion or rather a certain concept of truth e.g. *coherence, correspondence, or consensus concept*. The concept of truth constitutes limitation for evaluating design theories, e.g. the reference model, because such theories aim at intended artefacts or future worlds, e.g. business process model artefacts. However, the truth in evaluating design theories cannot be neglected. Researches refer to "relaxed truth" [24]. In other words, a design theory does not have to fit the current reality entirely, but it must be in the line with evidence. Thus, the assumptions underlying the prescriptive and descriptive parts of the reference model can be also evaluated in pursuance of the judgement of theories [238].

The *correspondence concept* of truth implies examining the assumptions of the reference model against reality. This requires a description of the model and its intended use as well as testing its activities against perceptions of reality. The *coherence concept* of truth implies that the reference model should be in line with an established body of knowledge, e.g. with research results and opinions found in acknowledged publications. It should not contradict accepted knowledge, e.g. established data flow diagrams principles. The *consensus concept* implies a discursive judgement by experts. This means to receive acknowledgment by people who can confirm the assumptions of the reference model.

Researchers identified are three generic principles that can differentiate a reference model as a result of scientific research from other sources of knowledge: *abstraction*, *originality* and *judgment* [24]. The reference model should *abstract* from uniqueness of single instances and from changes that may occur over time. However, it does not mean that abstraction causes the reference model to be faded out of the domain. It should rather be explicit and includes phases of how to apply it to a particular case. *Originality* of the reference model as a result of a scientific research is difficult to judge. It comprises elaboration on documentation of the reference model with respect to generic principles and long-term research goals. *Judgement* in science refers to the fact that there is given comprehensive reason/justification for any assumptions. Thus, researchers should refer to the preferred concept of truth and the related testing procedures. This applies to the descriptive parts of the reference model. The truth in relation to the prescriptive elements of the reference model is not an issue. Design decisions can be perceived reasonable/justified if they are the accepted state of the art (following the coherence concept) or a subject to discursive judgement by experts (following the consensus concept). Regardless, judgement entails that design decisions should be made explicit and given reasons for any choice [24]. Table 5.5 summarizes the discussion of the truth of design theories in relation to the reference model.

Table 5.5 The Truth of the Process Oriented Reference Model

Criteria	Description	The Process Oriented Reference Model
Coherence	In line with an established body of knowledge	It was built based on design science research paradigm synthesizing process oriented research practices which were found either in literature or during facilitating focus groups of practitioners.
Correspondence	Testing assumptions against reality	It was employed in various case studies and experimental design to assess its representational information quality. More details are provided in sections 5.4 and 5.5.
Consensus	Acknowledgment by experts	It was acknowledged and published at various information systems conferences and journals, e.g. [156,153]. Having engaged practitioners to build the reference model enabled to receive positive feedback by its users.
Abstraction	Applicable to many instances	It is used to build business process model artefacts in information systems field following design science research methodology.
Originality	Long term research goals	It details meta-design phase of design science methodology focusing on business process model artefacts. It helps determine general activities for this phase and further detailing this methodology
Judgement	Reasons for any assumptions	It was build based on two processes: literature review and collaboration with practitioners using the same modelling techniques. Justification of each element of the process is provided in the section 2.2.5 and chapter 4.

5.4 Deployment

The deployment perspective takes into account criteria which are relevant for people working with a reference model. They may consider criteria such as comprehensibility, compatibility with other artefacts being used in a research institution or availability of tools. Hence, the success of the reference model depends significantly on its users, e.g. design science researchers. It refers to their ability as well as their willingness to deal with the model. In order to foster communication between the stakeholders, a reference model should be understandable [24]. Section 1.4 indicated that one of the research objectives for the reference model is to build an artefact that is easy to understand. Within this deployment perspective, the focus is on this aspect; however, the other objectives are also considered.

The section 2.5 of the literature review chapter indicated that ease of understanding research objective represents one of the representational information quality dimensions. Upon a discussion with business partners of this research, it was concluded that the ease of understanding objective of the reference model should cover all the representational information quality dimensions. Hence, the research interest were extended and the reference model was evaluated by taking into account all representational information quality dimensions [109]. The other objectives of the model, as discussed in section 1.4 are *the type of data* which can be observed as the reference model is applied to build various business process model artefacts. Engaging practitioners and conducting literature review indicate *the academia and best practices* objective. Not bounding a research work to any technology outlines the *technology free* character of the model. In addition, it suggests some tools free of charge. *Feasibility* objective is met if the reference model delivers business process model artefacts following design science paradigm.

To address this deployment perspective and the research objectives, two experimental designs [189] were conducted. First one was examining the improvement of the perceived representational information quality between the reference model named in the experiment as *reference model guideline*, and the *general design science research guideline*, which referred to the hitherto identified phases of design science methodology [9] in building a business process model artefact of exactly the same objectives. The second one was examining the improvement of the perceived representational information quality between the business process model artefacts developed with and without the reference model. The second experiment used the artefacts built in the first experiment.

Both experiments present similar aims, the improvement of perceived representational information quality in relation to the reference model, thus some similarities in description of the experimental rationale, data collection and analysis apply. The following sub-sections describe them only once and indicate differences to each experimental design accordingly.

The sub-sections are organized as follow. The next one discusses the rationale of experimental designs, variables selected, and validity of measuring. Based on that discussion, the following sections present the experimental designs and executions. Finally, the tests for the obtained data and interpretation of results are discussed.

5.4.1 The Experimental Designs

As outlined in section 3.5.2 Popper [187] suggested that truth of a scientific statement or theory could be tested only by comparing two hypotheses that differ in a single respect. Mill [188] indicated that by comparing two situations that differ only in the presence of the causal variable, causality could be isolated. Both Mill and Popper pointed out to the fundamental importance of controlling all factors other than the one that is of interest to the scientist. Experiments are conducted following this rationale. Mill [188] proposed that causal factors could be isolated only by comparing two conditions: one in which supposed cause is present, and one in which supposed cause is absent. The variable that experimenters typically manipulate is the one they have proposed as a cause and in the simplest situation they manipulate it by changing whether the cause is present or absent. This manipulation is called levels of the variable. For example, two levels mean that the supposed cause can be present or absent. The variable that is manipulated is named the independent variable (it depends on the experimenter), the one that is not manipulated by the experimenter is called the dependent variable (the outcome of the experiment) [189].

In the first experiment, there was one independent variable: the type of guideline used, as it was to measure the impact of a research guideline on the design science research. It had two levels: the reference model guideline (presence of the additional phases for the meta-design phase in design science) or the general research guideline (absence of the additional phases) for development of a business process model artefact in design science research. The outcome of the experiment was the total scores of researchers rating of the representational information quality of the guideline, how good guideline represents information to researchers.

In the second experiment, there was one independent variable, the way in which a business process model artefact was developed. It had two levels: an artefact developed with the reference model guideline or the general research guideline following design science paradigm. The outcome of the experiment was the total scores of participants (in the experiment, they are referred to business model artefact stakeholders) rating of the representational information quality of artefacts. The main concern was how good the artefacts represent information to their stakeholders.

Experiment Validity

One important issue when deciding how to measure the dependent variable is validity. Validity refers to the fact that researchers measure what they think they are measuring [189]. Since in the experiments, a questionnaire measure of the experimental outcome is used, the content validity had to be considered. It refers to the items in the questionnaire, which must relate to the construct being measured. This is achieved if items are representative, not deliberately similar to other items, and questions cover the full range of the construct. In these experiments, to achieve the content validity, the questionnaire was built on the representational information quality dimensions [110], as discussed in section 2.5.1: concise representation, consistency, ease of understanding, and interpretability. Questions for each dimension were constructed based on their identified attributes [109]. In terms of measurement, an 11-point Likert type scale was used, as it is the most widely used approach to scaling responses in questionnaires [67]. The number 10 was labelled as “Extremely good”, while 0 as “Not at all”, and 5 as “Average”. Most questions in the questionnaire were formulated as “how <Attributes of the Item> is the artefact?” For example, “How easy is the artefact to understand?” The data then consist of each participant providing a score (rating) of how they found the artefact in terms of the quality of represented information. Appendix 7 illustrates the questionnaire.

Quality cannot be taken for granted or assumed. Instead, quality is a subjective term for which each person has his own definition [108]. Following reasoning of [189], one can be reasonable confident that a score of 4, in the questionnaire, refers to better representation than a score of 3 and that a score of 5 almost certainly represents information better than a score of 4. However, one cannot conclude by how much guideline having the score 5 is better compared to other guideline having the score 4 or a 3. A score of 4 might represent an enormous difference over a score of 3, whereas a score of 5 might represent only a minor gain over a score of 4 – or vice versa. In addition, it is probably not realistic to assume that if one participant rates one attribute (e.g. ease to find key points) of the guideline as 3 then the attribute of the guideline is, in reality, half as good as the same attribute of a different guideline which was rated as 6. One might question whether two guideline which both were rated as 6 are likely to be equally good. Hence, this data (ratings) is treated as ordinal data (i.e. an arbitrary numeric scale where the exact numeric quantity of a particular value has no significance beyond its ability to establish a ranking over a set of data points [239]). This assumption is important in the selection of parametric or non-parametric tests for the data. The non-parametric tests are applicable for ordinal data, whereas measurement on an interval or ratio scale is applicable for a parametric scale [189]. Since, the scores of the questionnaire are treated as ordinal data, a non-parametric test is selected. The data analysis for each experiment is further described in the section 5.4.4.

There are different ways in which validity of results can be assured [194]. If obtained data are due only to the manipulation, then there is no lack in internal validity. Selecting an appropriate experimental design gives reasonable confidence for internal validity. In the first experiment, independent measure design is used, whereas in the second, repeated measure design is applied. Selection of these is discussed in the following the section 5.4.2. If findings are not only valid for the specific situation within which were obtained, then there is no lack in external validity. To achieve this, the experiments would need carrying out multiply times in different environments to be on reasonable safe ground of the prediction. However, due to the research financial and time limitations, these experiments show lack of external validity. Next section elaborates on the reliability side of the experiments.

Experiments Reliability

Validity is a necessary but not sufficient condition of a questionnaire in the experiments [240]. A second consideration is reliability. Reliability is the ability of the measure to produce the same results under the same conditions [189]. To be reliable the questionnaire must first be valid [240]. One of the ways to assess scale reliability of questionnaire is to test the same group of participants twice [189]: if the questionnaire is reliable a researcher would expect each participant’s scores to be the same at both points in time. So, scores on the questionnaire should correlate quite well. However, in the real experimental environment, if the researcher tested the same participants twice then they would expect some practice effects and confounding effects, people might remember their responses from last time, and testing twice is time-consuming. There are statistical methods to overcome this problem. Cronbach [241] suggested splitting the data in half in every conceivable way and computing the correlation coefficient for each split. The average of these values is known as Cronbach's alpha, which is the most common measure of scale reliability [189]. An acceptable value for Cronbach's alpha is a value greater than 0.7 [242]; values substantially lower indicate an unreliable scale. Test of reliability applies upon data of the experiment is collected. In this first experiment, answers from 56 respondents were found. In the second one, 100 answers were collected. Details on setup and selection of respondents are discussed in the following sections. SPSS software was used to calculate Cronbach's alpha to determine to what degree the questionnaire is successful in constructing questions that measure either a researcher's or participant's opinion. Results in Table 5.6 indicate a reliably acceptable scale of the questionnaire.

Table 5.6 Reliability Analysis

First Experiment			Second Experiment		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.758	.735	11	.707	.708	11

The following sections, first describe the first experimental design and then the second one followed by data analysis.

5.4.2 First Experimental Design

This first experiment examined the difference in the quality of information representation of the reference model and general research guideline in design science paradigm. Participants (students) were asked to conduct design science research on business process models and provided them with either the reference model guideline or the general design science research guideline. Once the time for conducting the research ended, they were to respond to the representational information quality questionnaire, discussed in the section 3.5.2.

Participants of this experiment were 3rd year students of information systems from two institutions that provide third-level education in English language. Students were between 20 and 22 years old (*M* 22, *SD* 1), and had never conducted both design science research and process oriented research. This had been assured during interviews with them and lecturers of the institution prior to the experiment. Although 80% of the students were not native English speakers, they had Cambridge Certificate of Proficiency in English equal or greater than grade C.

In this experiment, a two-group independent measures design [189] was used. This design uses separate groups of researchers for each of the different conditions in the experiment. It divides participants randomly into two groups, and gives one group (the 'experimental' group) some treatment (e.g. the reference model guideline) which is not given to the other group (the 'control' group). The performance of the two groups is then measured: if it differs, then one can be reasonably confident that the difference is attributable to the experimental manipulation (see Figure 5.1). The perceived quality of information representation in both general and reference model guidelines was measured after researchers finished their work. a sample of 28 researchers per group was used.

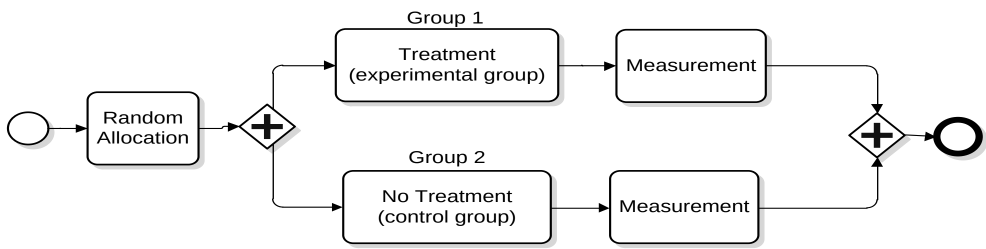

Figure 5.1A two-group independent measures design [189]

In the Figure 5.1, the treatment refers to the condition where the experimental group was provided with the reference model guideline. No treatment is the condition where the group was assigned to the general design science research guideline to follow in their research. Measurement is the phase where the questionnaire was provided. It had been hypothesised that participants would experience better information quality of the reference model guideline than aggregated methods selected on their own with the general research guideline in a process oriented design science research.

The entire experiment followed an independent-measures design. Each participant could only be in one group, and could only give one score – their rating of perceived quality of information provided. The independent-measures design was applied, as oppose to repeated-measures design (the same participants in two groups) [189], because participants had to be the first-time design science researcher. Their level of experience is probably unlikely to be the same on subsequent process research in design science, and so each person could participate only once.

This measure design was selected for several reasons as discussed in the following. The experiment was easy to explain and to carry out. The key point was to assign participants randomly to the groups. The fact that participants occurred only in one condition prevented from receiving slightly more or less different responses in different experimental conditions. That reduced the chance of practice and fatigue effects. There was no possibility that performance in one condition can affect performance in another, as each participant participated in only one of the condition. If participants had been switched between group 1 and 2 for another process research, they could not have had meaningfully participated in the experiment due to their previous experience and fair familiarity with methods and procedures.

However, there are some drawbacks of this design. This design is less sensitive than a repeated-measures design. In an ideal world, the only differences between participants in the two groups would be that those cancelled out in the group 2, and not those in the group 1; therefore any differences between the groups would be due entirely to the experimental manipulation [189]. However, within each group, there are all kinds of differences between participants that might act to add variances to the data. Some participants in each group would have different research motivation, attention to detail, or frame of mind. As a result of all these factors, participants' scores within each group are likely to show variation between the members of that group. Due to these factors that are outside of the direct control, the degree of the experimental effect will probably vary from participant to participant. However, a systematic variation in performance was expecting, because there was one type of behaviour towards all of the participants in group 1, and in a different one to all of the participants in group 2. If anything else produced systematic variation in performance, it would become hard to interpret the results. Hence, the participants were allocated to the two conditions randomly, Figure 5.1. It decreased the chances of any systematic differences between the groups on any variable other than the one that was manipulating experimentally.

Procedure

56 participants were split into two groups at random. A group 1 (the experimental group) was supplied with the reference model guideline. A group 2 (the control group) was given the general research guideline with indication for 3 main activities in a meta-design phase, according to the Figure 2.6, to consider. Every participant in each group was asked to carry out design science research to build business process model artefact of IT service requests for a public organisation associated with their university.

The research project focused on business process model for IT service catalogue. Each group followed the design science research paradigm, and was given the following *research motivation*. The act of transforming resources into services is the base of the service management and without it an organisation is just an aggregate of resources that by itself does not bring value to the business [243]. Moreover, IT departments are mostly imposed to justify their services only from a cost-benefit perspective [244]. Participants were asked to look into the transformation from resources into IT services. *Objective of a solution* was a business process model artefact which identifies IT services through incidents. It should aim to reach accurate identification of IT services, reduce the gap between the services provided by the organisation and users' perception of these services. It was summarized as follows: when an incident is created, it implies the existence of the service in the organisation. The incidents for the purpose of creating artefacts came from the incidents database of a public organisation. Participants spent over 3 months on that research project having access to the incidents database, two practitioners assigned to the projects who dedicated 2 hours of their time a week to answer participants' questions, and college resources such as library and e-libraries of scientific publications.

Measurement was taken based on how information was presented to the participants by either the reference model in the group 1, or methods and procedures selected and aggregated by participants in the group 2. This means that participants in group 2 had to examine and select methods and procedures for their general research guideline that they used throughout the research. This was necessary because as established in the section 2.2, the general design science research guideline did not provide any specific ones. For example, participants in group 2 were free to choose any methods for conducting their literature review. All those used methods and techniques altogether were treated as the alternative to the reference model, and therefore the same questionnaire was used. The assumption was that the methods were needed to achieve a certain research goals. The techniques were followed so long as the basic assumptions behind the method were adhered. [245]. Once every participant in each group finished developing the business process model artefact in design science paradigm, they were provided with the questionnaire. Participants filled in the questionnaire on individual basis. First 5 minutes were assigned for explanation of the paper form questionnaire. Then, participants had 10 minutes to provide answers. Each participant was asked to bring their set of methods that had been used to carry out the research so that they could refer to them while filling in the questionnaire. Upon collecting all questionnaires the experiment was over, and the data was digitized for analysis. The section 5.4.4

discusses the applicable test for the obtained data, and present calculations with interpretation of results.

5.4.3 Second Experimental Design

This experiment examined the difference between the artefacts in terms of improvement of the perceived representational information quality. The stakeholders of artefacts, hereinafter called participants, were asked to examine two artefacts, first developed with the reference model and the second one without it, following the design science research paradigm. Then, they were asked to respond to the questionnaire.

Participants of this experiment were stakeholders of a public organisation. The organisation provided IT services for various departments. The practitioners in the numbers of 50 were between 29-58 years of age (*M* 43, *SD* 3.4). The gender was split in 37 males, and 13 females. All were free from any obvious physical or sensory impairment. Their work experience in the organisation was between 0.5 to 12 years (*M* 5, *SD* 1.3). They role mainly were engineers from fields of electronics, design, architecture, and computing. Participants took part in the experiment willingly, and therefore, it was assumed their responses to the questionnaire were genuine.

This experiment used a basic two condition repeated measures design outlined in Figure 5.2 [189]. Under this design each practitioner was randomly assigned to the order in which the artefacts were examined. The improvement was measured after examining each artefact. To maximize the chances of finding a difference, a sample of 50 participants was used. Each participant took part in both conditions (they examined both artefacts). The order in which artefacts were assessed was counterbalanced (see Figure 5.2), and there was a delay of 20 minutes between examining the artefacts.

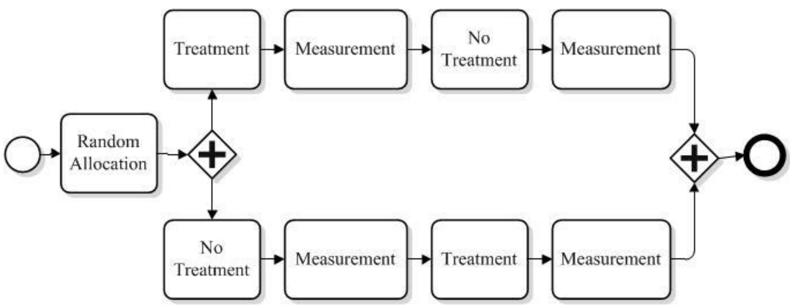

Figure 5.2 A basic- two condition repeated measures design [189]

In the Figure 5.2, the treatment represents one condition in which the business process model artefact was developed with the reference model. No treatment refers to second condition in which the other business process model artefact was developed without implication of the reference model in design science research. Measurement is the phase where the questionnaire was provided. It had been hypothesized that having used the reference model to develop a design science process oriented artefact would lead to greater information quality than following design science research methodology without the reference model. Developing an artefact without the reference model refers to the fact that researchers were free to imply any method (from the scope of design science paradigm) to the general design science research methodology [9] while carrying out the design science research. Development of an artefact with the reference model imposed methods on researchers as described in chapter 4.

The entire experiment followed a repeated measures design (within subjects design) [240]. The same participants were used in every condition – so they produced one result for every condition of the experiment. This design was selected for two reasons. One was the fact that it was more economical to run in terms of time and effort. The same participant was used twice. The second reason was sensitivity. The aim was to find the differences in the results which had been produced by the experimental design. These differences would become clear only after reducing all the random 'noise' produced in the data by the fact that participants differed from each other. In this repeated-measures design, there are only a few sources of random variation to vague the effects of the manipulation of the independent variable. Usually, researchers need to deal with differences in the experimental conditions, random differences between individuals within a group, and random differences between individuals in one group and individuals in another group [189]. In repeated-measure design the last aspect is eliminated. Hence, all the efforts are put on the individual variation in participant's response to the experimental manipulation.

However, there are some drawbacks of this design. Although the manipulation had no effect on participants' behaviour, they could still give slightly more or less different responses in the different experimental conditions. If researchers observed merely a random fluctuation in the performance, this would not be a problem because this behaviour should cancel out across conditions. However, systematic variations in performance may cause some issues. Participants could get bored with time and better practise at examining the artefacts, for example. These systematic effects may interact with the manipulations of the independent variable and reduce interpretability of the results, so called 'carry over effect' from one condition to another [189]. For example, if each participant took part in each condition, in the same order, and the researchers found satisfactory differences in the manipulation, they would not be able to tell if the effect was due to manipulation or due to practice. To avoid the 'carry over effect', the order was counterbalanced, half the participants got the conditions in order A then B and the other half got the order B then A.

Procedure

For this experiment two artefacts were used, one developed with the reference model and the other without it. Each artefact was developed accordingly to the same research objectives, and represented a business process model of an IT service requests that this public organisation will use. These were two artefacts: one was selected at random from each group of the first experimental design (section 5.4.2).

The examination of those artefacts was conducted between 10 a.m. and 1 p.m. in the conference room of the public organisation. Within first 20 minutes, participants were allocated to each condition. A random number generator of a computer was used. As each participant arrived, a rule such as was addressed: if the next random number is even, the participant goes to the conditions with order A then B (Figure 5.2); if it is odd, the participant goes to the conditions with order B then A. This way, it was ensured that participants were not likely to produce systematic differences between groups of the orders of conditions. For example, by assigning all the participants who turned up on time to one condition, and the other all participants who came late to another condition,

Once everyone was assigned to a condition, the artefacts were provided accordingly. 5 minutes were given to explain under which angle the participants should examine the artefact. It was followed by another 5 minutes to explain the questionnaire in a paper form. Afterwards, the thorough examination was allowed for 30 minutes. Then, the questionnaire was provided, which was not available during the examination, and allowed 10 minutes to provide answers. Participants still had access to the relevant artefact. After this stage, there was 10 minutes break during which the questionnaires were collected and artefacts swapped accordingly. The following examination phase looked similar: 30 minutes examination, and 10 minutes for answering questions. There was no explanation, since the same participants were participating and the time-delay was minor. Upon collecting all questionnaires the experiment was over, and the data was digitized for analysis.

The following section discusses the applicable test for the data obtained, and presents calculations with interpretation of results.

5.4.4 Data Analysis and Results

As discussed in section 5.4.1, the data measurements from the questionnaire in both experiments were at the ordinal level; the non-parametric tests were considered. Since, two different measure designs are used for the experiments, different non-parametric tests apply. These are discussed in the following.

First experiment – non-parametric test

Using the chart in Figure 5.3 together with the discussion above, a test to run on the data from the first experiment is determined. Beginning from the top, the data consists of scores; so that rules out Chi-Squared as an option. Chi-Squared applies when you have nominal (categorical) data with each person contributing only once to each category. An experiment design rules out correlations. Correlation is when a researcher looks for relationships between variables without manipulating them, as it is done in an experiment. In the first experiment, there is one independent variable and the independent-measures design. There are two groups: one group uses the reference model, and the other uses the general research guideline. Hence, the choice can be narrowed down to either an independent-measures t-test, or its non-parametric equivalent, Mann-Whitney test. Since the data does not satisfy the requirements for a parametric test, the Mann-Whitney test on the data is chosen.

The Mann-Whitney test is used for testing differences between groups when there are two conditions and different participants have been used in each condition. In this experiment each participant carried out one business process research and provided scores only for one guideline, which their used. The total scores of how well information provided by guideline fits for use of process oriented research were measured. It was hypothesized that the reference model guideline in process oriented design science research would give better scores on the representational information quality than general research guideline. SPSS software was used to run the Mann-Whitney test.

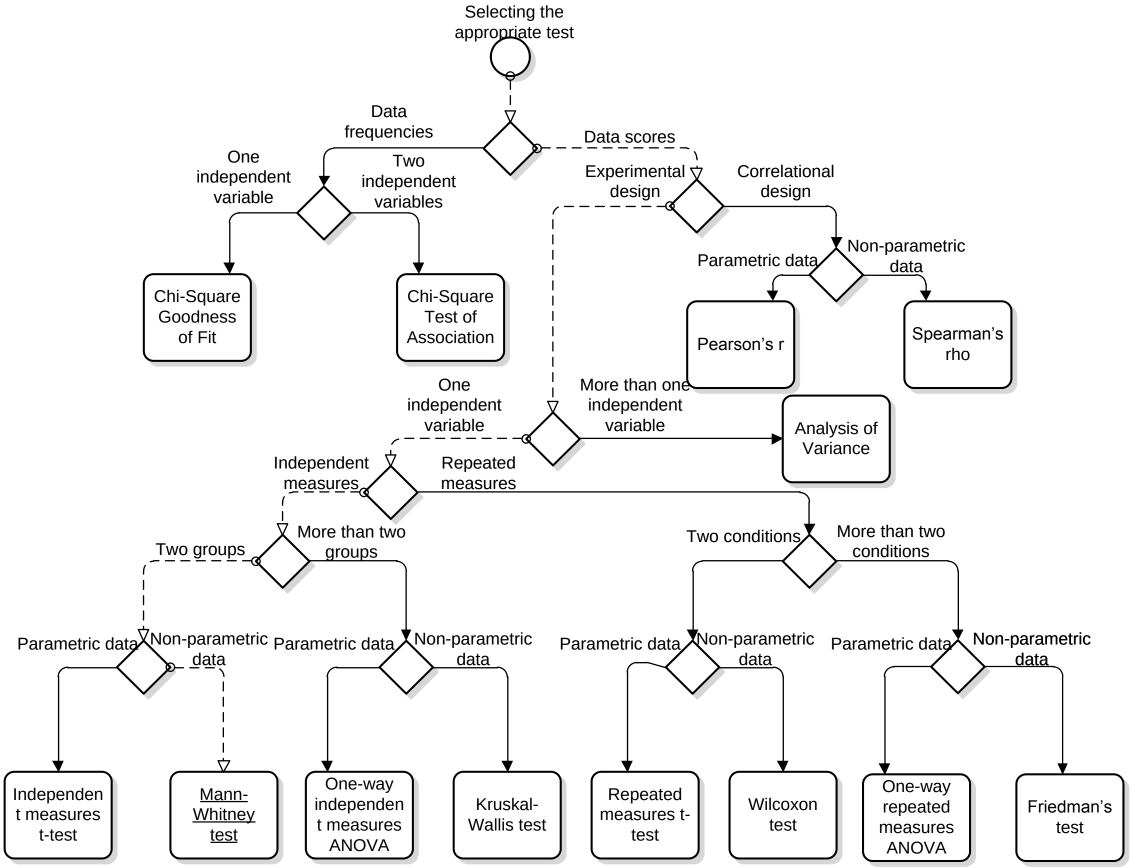

Figure 5.3 Selection of the appropriate test for the data [189]

Mann-Whitney test ranks the data for each condition, and then examines how different the two rank totals are. While ranking data, it is ignored to which group they belong. The lowest score gets a rank of "1", the next lowest gets a rank of "2", and so on. If two or more scores are identical, this is a "tie".

If most of the high ranks belong to one condition and most of low ranks belong to the other one, then there is a systematic difference between conditions. As a result, the rank totals will be quite different. In contrast, if the two conditions are similar, then high and low ranks will be distributed fairly evenly between the two conditions and the rank totals will be fairly similar. Since, differences in the ranked positions of scores in two groups are analysed. Table 5.7 summarizes the data after ranking.

Table 5.7 Mann-Whitney Rank Rest

	Condition	N	Mean Rank	Sum of Ranks
Total Score of Representational Information Quality	the reference model guideline	28	33.61	937.50
	the general research guideline	28	23.39	658.50
	Total	56		

The scores are ranked from lowest to highest. The group with the lowest mean rank has more low scores in it than the group with the highest mean rank. Table 5.7

shows that the mean rank of the reference model guideline different from the mean of the general research guideline, but the actual Mann-Whitney test will confirm whether this difference is large enough to be statistically significant (i.e. unlikely to have occurred by chance). Table 5.8 provides the actual test statistic for the Mann-Whitney test. It contains the value of Mann-Whitney's U statistic, the value of Wilcoxon's statistic and the associated *z* –score (which indicates how many standard deviations an observation or datum is above or below the mean), and the significant value of the test.

Table 5.8 Mann-Whitney Test Statistic

	Total Score of Representational Information Quality
Mann-Whitney U	249.000
Z	-2.348
Asymp. Sig. (2-tailed)	.019

a. Grouping Variable: Condition

The value of Mann-Whitney's U can be interpreted using printed tables of critical values or the *z*-score to compare it against critical values of the normal distribution. This leads to the exact significance value (p=.019), which gives the two-tailed (for non-directional hypothesis) probability that magnitude of the test statistic is a chance result. *Z*-score helps calculate the size effect of the experiment.

The two-tailed probability is significant because the significance value (p=.019) is less than .05. In addition, a specific prediction had been made that researchers would experience better information quality of the reference model guideline than aggregated methods and procedures selected on their own (i.e. the general research guideline) in process oriented research. Thus the probability was halved to give the one-tailed (for directional hypothesis) probability (.019/2 = .0095), thus the significance is even higher. This finding indicates that reference model guideline and the general research guideline do significantly differ in the quality of represented information. If we look at the ranks for each group, Table 5.7, we see that the mean rank for the reference model was (33.61), and for the general research guideline was (23.39), hence the ranks of the reference model guideline were significantly greater than the ranks of the general research guideline.

Second experiment – non-parametric test

Using the chart in Figure 5.4 together with the discussion of non-parametric character of the data, the test to run is determined. Beginning from the top of Figure 5.4, it is known the data consist of scores; so that rules out Chi-Squared as an option. An experiment design rules out correlations. In the second experiment, there is one independent variable and a repeated-measures design. There were two conditions: an artefact developed with the reference model and without it. Thus, the choices of a test can be narrowed down to either a repeated-measures t-test, or its non-parametric equivalent, Wilcoxon test. Since the data does not satisfy the requirements for a parametric test, the Wilcoxon test is selected.

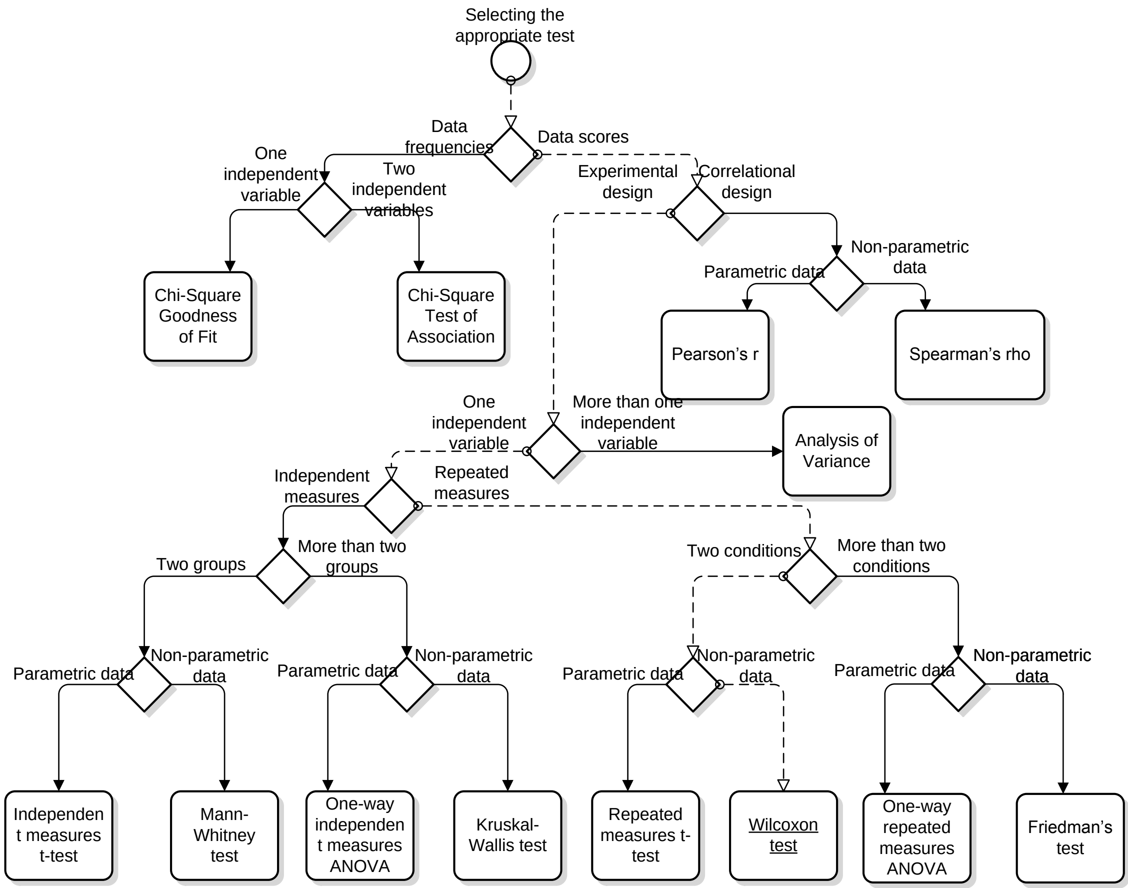

Figure 5.4 Selection of the appropriate test for the data [189]

The Wilcoxon signed-rank test is used for testing differences between groups when there are two conditions and the same participants have been used in both conditions. In this experiment each participant examined both artefacts (developed with or without the reference model). The total scores of how well information provided by artefacts fits for use after developing them with or without use of the reference model were measured. It was hypothesized that using the reference model for business process model artefacts in design science research would improve their quality of information provided. SPSS software was used to run the Wilcoxon test.

The Wilcoxon test first examines the difference between each pair of scores in the two conditions, and then ranks these differences for further examination. It compares the ranks of each participant regarding the artefact developed with and without the reference model. The differences between ranks can be positive (the rank in condition two is bigger than the rank in condition one), negative (the rank in condition two is smaller than the rank in condition one) or tied (the ranks in the two conditions are identical). Table 5.9 shows a summary of these ranked data. It tells the number of negative ranks (i.e. participants scoring better the artefact developed without using the reference model rather than with it) and the number of positive ranks (i.e. better scores of the artefact developed with the reference model than without it). The footnotes (a, b, c) under the table help determine to what condition the positive and negative ranks refer. The Table 5.9 shows that 6 of the 50 participants found better information quality of the artefact developed without the reference model, whereas 43 of the 50 participants favoured the artefact developed with the reference model. There was 1 tied rank (i.e. a participant who equally assessed both artefacts). The table also shows the average number and the sum of negative and positive ranks.

Table 5.9 Wilcoxon Signed Ranks Test

Ranks	N	Mean Rank	Sum of Ranks
Negative Ranks	6[a]	3.50	21.00
Positive Ranks	43[b]	28.00	1204.00
Ties	1[c]		
Total	50		

a. developed with the reference model < developed without the reference model

b. developed with the reference model > developed without the reference model

c. developed with the reference model = developed without the reference model

Wilcoxon test can be converted to a *z*-score, which indicates how many standard deviations an observation or datum is above or below the mean. In other words it enables to calculate the exact significance values based on the normal distribution. Table 5.10 tells that the test statistic is based on the negative ranks, that the *z*-score is -5.886 (negative means that it is below the group mean) and that this value is significant at p= .0003 (i.e. very high significance indicates that those scores very unlikely happened by chance).

Table 5.10 Wilcoxon test converted to z-score

	developed with the reference model - developed without the reference model
Z	-5.886[a]
Asymp. Sig. (1-tailed)	.0003

a. Based on negative ranks.

Most participants fall into the category with positive ranks; this is because the mean rank is higher for the positive ranks. This means that most people fell into the category of scoring better for the artefact developed with the reference model. There were significantly more people who had positive ranks than had negative ranks.

Therefore, it can be concluded that significantly information provided by the artefact developed with the reference model is of better representational information quality. This is in the direction to the hypothesis, so the 1-tailed significance value (.0003) is used.

Data Display

A good way to display non-parametric data is by using a boxplot diagram [189,109]. Non-parametric tests are not testing differences between means; they are testing differences between ranks. As discussed in section 5.4.1, the experiments deal with ordinal data, and therefore comparing means is not good representation of the data. Hence, boxplot shows the median (the middle score), and so better represents what the non-parametric test is examining. Figure 5.5 shows the data on such a diagram. The shaded box represents the range between which 50% of the data falls. The horizontal bar within the shaded box is the median. The 'I' shape shows the limits within which most of all of the data fall. The lower bar is the lowest score and the upper bar is the highest score in the data.

Figure 5.5 illustrates that the median number of total scores of representational information quality, in the first experiment was higher for the reference model guideline than the general research guideline. The fact that the median is higher for the reference model guideline confirms the direction of the conclusion that researchers find better fit for use of information provided by the reference model guideline than general research guideline which gives the opportunity for self-selection of methods and procedures for process oriented research. The second experiment showed that after using the reference model to develop an artefact the median number of total score of information quality was higher than without the model being involved in the business process model artefact in design science research. The fact that the median is higher with the reference model confirms the direction of the conclusion, this is the information provided by the artefact developed with the reference model is of better representational information quality.

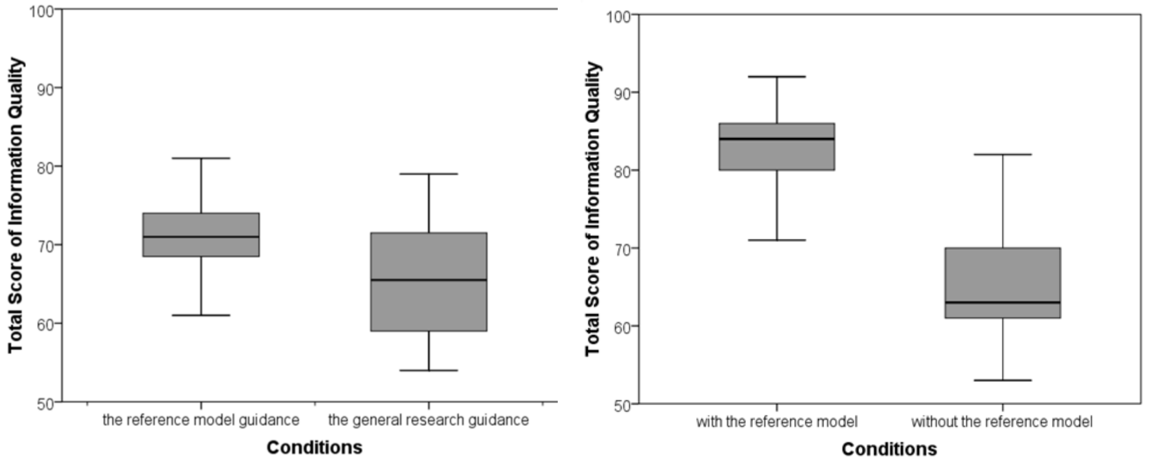

Figure 5.5 Boxplot for the first experiment (left) and second experiment (right)

The Effect Size

The fact that both test statistics were significant did not mean that the effect they measured was meaningful or important. The solution to this is to measure the size of the effect that they were testing. Measuring the size of an effect either by experimental manipulation or observation of the strength of relationship between variables is known as an effect size [189]. It is an objective and standardized measure of the importance of observed effect. There are many measures of effect size, but the most common one is Pearson's correlation coefficient [246]. It looks at the proportion of total variance in the data that can be explained by the experiment, which is equal to r^2 (coefficient of determination). Since this is a proportion, it must have a value between 0 and 1. 0 means that the experiment explains none of the variance at all. 1 means that the experiment can explain all of the variance. It can also have minus values (but not below -1), however, in experimental manipulation the sign of r merely reflects the way in which the experimenter coded their groups [240]. Generally, the bigger the value is the bigger experimental effect. By taking a square root of this proportion, the Pearson correlation coefficient, *r*, is determined. It is constrained to lie between 0 (no effect) and 1 (a perfect effect). It provides an objective measure of the importance of the experimental effect. There are some widely accepted suggestions about what constitutes a large or small effect [247]:

- r= 0.10 (small effect): in this case the effect explains 1% of the total variance.
- r= 0.30 (medium effect): the effect accounts for 9% of the total variance.
- r= 0.50 (large effect): the effect accounts for 25% of the variance.

These guidelines are used to assess the importance of the experimental effects. The equation to convert a *z*-score into the effect size estimate, *r* is as follows [248]:

$$r = \frac{Z}{\sqrt{N}}$$

In the first experiment, the Z is the *z*-score that can be obtained from Table 5.8, and N is the size of the study (i.e. number of observations). The effect size is therefore:

$$r = \frac{-2.348}{\sqrt{56}} \; r = -0.314$$

This represents a medium effect of the experiment (it is close to Cohen's benchmark of 0.3), which tells, there truly is difference between the reference model and the general research guideline in information representation for process oriented research. The effect accounts for 10% of total variance.

In the second experiment the Z is the *z*-score that can be obtained from Table 5.10, and N is the size of the study (i.e. number of observations). The effect size is therefore:

$$r = \frac{-5.886}{\sqrt{100}} \; r = -0.5886$$

This represents a large effect of the experiment (it is close to Cohen's benchmark of 0.5), which tells, the effect of whether the artefact developed with or without the reference model was examined was a substantive effect. The effect accounts for 35% of total variance.

Interpretation of the Results and Findings

The first experiment outlined that the number of total scores of information quality for the reference model guideline (*Mdn* = 71) was significantly higher than for the general research guideline, and the effect is substantial in real terms (*Mdn* = 65, *U*= 249, $p < .05$, $r = -0.314$). It can be said that the reference model explains 10% of the total variability in total scores of the quality of the information provided to participants.

The second experiment outlined that the number of total scores of information quality after examining the artefact developed with the reference model (*Mdn* = 84) was significantly higher than after examining the artefact developed without the reference model (*Mdn*=63, *T*= 21.00, $p < .05$, $r = -0.5886$). It can be said that usage of the reference model explains 35% of the total variability in total scores of the representational information quality of artefacts. The difference is statistical significant ($p < 0.5$), and the importance is medium (35%).

Although, the main focuses in these experiments were put on the representational information quality for the reference model and its outcomes, other research objectives were also evaluated. The type of data objective applied because participants in the first experiment were able to use the reference model in a particular instance for business process model artefact. They developed business process models for IT service requests. Participants of the second experiment identified legitimacy of these artefacts. Moreover, it was observed how the reference model engaged and facilitated the limited resources of domain experts. The participants of the first experiment constructed their artefacts with knowledge from literature and meetings with two practitioners from the field. There were no costs in regards to supporting software for the research. Participants used free tools indicated in Table 4.10. In the group that was not provided with the reference model, it was observed that tools mainly came from typical office suits and in 7 cases there were applications on trial periods.

Feedback received from the participants of the first experiment pointed towards a direction that enabled a refinement of the reference model. They suggested the interviews with practitioners could be divided into two parts: 1) Questions regarding the interviewee's position in the field 2) Questions regarding the business process model investigated. Some of the participants had a list of questions which were used accordingly to the flow of the interviews. In terms of the time of the interviews, the first interviews lasted up to 90 minutes, the following ones up to 45 minutes. Participants said that following the agenda was challenging as interviewee provided many answers out of the scope of the business process model investigated. These comment required to provide more preparatory activities prior to the interviews in the reference model.

This section only presented business process model artefacts built in the environment of the experimental designs. The following section presents feasibility of the reference model in complex business process model research projects following design science paradigm.

5.5 Engineering

This perspective aims at evaluating the reference model as a design artefact which can be regarded as a specification of possible solutions to a range of problems. From this engineering perspective, two concerns are covered: whether or not the reference model fulfils its objectives and whether or not it supports its intended purpose [24]. Testing a model against its objectives implies the objectives to be made explicit in a comprehensive and precise way. Objectives include a definition of the intended application domains as well as a definition of the purposes to be satisfied. The objectives of the reference model are outlined in the Table 1.1 of the section 1.4. They include the following. The reference model takes into account the perspectives of academia and best practices and its design outcomes; it concerns the type of data as opposed to the data instances; ease of understanding; technology free; and feasibility. All the other perspectives in this evaluation of the reference model took into account these objectives as well; however, only the engineering perspective enables for thorough examination of the feasibility requirement. Feasibility refers to the second concern of this perspective – the support of its intended purpose. This is to demonstrate that the reference model supports building business process model artefacts in design science research. In other words, this is to adapt the reference model to individual design science research objectives of a business process model artefact.

The section 3.5 presented the research design and justification of selection of a case study method in the evaluation of the design artefact – the reference model. This method applies to the engineering perspective due to its capabilities of the approach that seeks to understand a problem being investigated. It provides the opportunity to state design science research question and to capture and observe the richness of the application of the reference model in a natural research setting that enables to outline its feasibility. Moreover, the method allows understanding the nature and complexity of the process taking place, and valuable insights can be gained to draw generalized conclusions for activities in meta-design phase of design science research methodology. The generalized conclusions of this research are outlined in the section 5.6

The reference model is in form of a business process model. It takes one or more kinds of input and creates an output that is of value to the research stakeholder (e.g. the enterprise partner of the research). The section 3.5.1 outlined that the order and activities included in the reference model were validated and are the result of the approach taken during the construction of the reference model. This can constitute a so called self-validation. By constructing a business process model artefact (the reference model), activities and their order were identified that can state as the reference model for other business process model artefacts. Thus, the reference model already showed its capabilities to build a desired business process model artefact in design science paradigm (i.e. while building itself). However, by having involved the reference model in more design science research projects, it can be demonstrated how it meets its specifications. The following sub-sections demonstrate case studies that applied the reference model in pursuing their design science research objectives of business process model artefacts. Due to the complexity of design science research projects, the below case studies presented cover the representative aspects of the reference model. These are the literature review and modelling, and collaboration with practitioners and modelling.

These case studies embrace at least one of the source processes. The various demonstrations cover all aspects in sufficient details. Thus, that the evaluation was done to a reasonable effort to validate the reference model.

5.5.1 Case Study on Innovation Value Measurement

The following demonstration of a case study describes the application of the collaboration with practitioners process (introduced in section 4.3) of the reference model for business process model artefacts in design science research. In the period of March 2012 until November 2012, a business process model artefact was constructed that guides senior managements through an innovation process and indicates the points where the value of on-going innovation project can be measured. During the course of the design science research, the process oriented reference model artefact was applied.

The following first introduces the research motivation, problem and briefly findings of the literature review. Then, the course of collaboration with practitioners is described in detail. Finally, the results are presented.

Problem identification for this research started during industrial meetings of senior managers. They were facing the challenge of measuring innovation which has to be measured like everything that businesses do which involves the investment of capital and time. However measuring innovation presents problems for the process itself that is to be measured. It was also stated that the risk which the innovation process requires if it is attempted to measure the wrong things at the wrong time. These senior managers coming from various enterprises decided to work together in order to design the desired business process model for measuring innovation. In order to achieve that, they followed design science research and struggled with its execution. This was a good opportunity to show application of the reference model, how it facilitates collaboration with practitioners from different industries and provides the business process model desired.

Following the model, the research scope was narrowed down. The results are presented in the Appendix 2. That was followed by the next phase which was to determine the scope of the collaboration, accordingly to the Figure 4.8. The analysis of the topic, the involved participants, and resources were conducted. The task analysis was formulated as a business process model capable of measuring the value of innovation realized by a firm. The deliverables was to represent the process in BPMN. Overall, seven participants from five companies were involved in the focus group collaboration. They participation was voluntarily and motivated by the opportunity to share experience and best practices between parties involved. Finally, the resource analysis concerned the available time. Each company dedicated 90 minutes slot for individual interviews on their site, and 5 hours for a group meeting. One of the company provided software (listed in Table 4.10) to facilitate online meetings. In addition, mind map software was used to make notes and visualize insights provided by participants. The participants' roles in their organisations were linked close either to facilitation of innovation projects or execution.

The focus group collaboration followed the activities listed in Table 4.7 and selected methods from Table 4.9 (see section 4.3.3). In the step 0, questions for individual interviews were prepared. The questions were split into two sections. First section was to understand and determine participant's connection to the innovation process and its measurements. Thus, the questions were formed around their organizational units, daily activities, main responsibilities, and personal understanding of the innovation process. The second section referred to questions that could allowed for further elaboration on participant's expertise regarding the desired process. For example, the questions of the second section regarded a formal measurement methodology in place of a particular organizational unit, people involved in innovation value measurement, milestones and activities of measurement, as well as metrics used. These rather general questions were later decomposed into more detail sub-questions as the interview progressed.

In the step 1, the interviews with each participant of the focus group were conducted. This phase was divided into two activities (B1-B2). First, questions from the first sections were asked to understand and get to know a participant's expertise and perspective to the process. Hence, the researcher followed laddering interview method and only the first section of questions was asked. Answers were put and visualized on a mind map. There was 40 minutes allocated for this part. At many occasions participants had prepared presentations prior to the interview and additional time was needed. These presentation provided overview of the organisation and the context of innovation they were into. The last 50 minutes of the interview was dedicated to the business process investigated. As the interview was progressing, a sketch of the process was being updated and displayed on the mind map software in order to allow the participants to track correct interpretations of their saying. For the B2 step, semi-structured interviews were chosen. In addition a transcript of each interview was sent for an authorization with a request for clarification of ambiguities that were discovered after the interview took place.

In the step 2, all transcripts of the interviews were summarized and distributed to all participants prior to the focus group meetings. One of the goals was to provide all participants with the same amount of knowledge, so that at the focus group meetings more insights could be delivered. The key finding at this stage of the research was a clear distinguish between measuring innovation as facilitator and technical IT. Along with the summary of transcripts, an overview of the agenda for the focus group meetings was provided.

The following step 3 describes activities of the focus group meetings. An ice breaker and focus group work methods were applied from the Table 4.9. Since, some participants could not attend the meeting in person; the meetings were carried out through an online collaboration tool. All participants in the room had a logged in PC to the tool and all questions and summary of answers were put through that tool. The online tool generated reports of all typed in words so that enhanced the analysis of the meeting at later stage. The meeting began with an introduction of the meeting agenda followed by allocation of 5 minutes for each participant to introduce their organisation, roles, and relation to the innovation process. This was a result of a simple ice breaker method to catch up with each other. The participants knew each other from the time the focus group was established. The rest of the focus group meeting was structured accordingly to the focus group work method, as discussed in the section 4.3.3. Each participant was provided with the process of measuring innovation derived from their interviews. Then, each participant presented and described the process model to the rest of the group so that everyone got an overview of possible perspectives to measure value of innovation projects. Anyone was allowed to ask questions to the presenter after each presentation. In addition, after each presentation, there was 5 minutes brainstorming, so that some additional insights could be added to the model, e.g. metrics, activities. Once all the business process models were presented a poll was introduced. The most comprehensive process model was selected as a core to which additional activities from other process models were added. The following activity required from participants to work together to build the business process model of measuring innovation value based on the most voted process model and the other ones presented. The most voted business process model was displayed and participants could make suggestions what else should be added. If majority of participants did not raise any objections the suggestion was added. The mind map software was used to move activities of the process for the final consensus. The focus group meeting ended roughly after 5 hours including 30 minutes break. For the step 4, a short 40 minutes conclusion meeting was organized at which the business process model for measuring innovation value was presented.

Feedback received upon and observations made during this case study enabled a further refinement of the reference model. Participants suggested that the transcripts of the interviews should be in a narrative form and divided into two documents. First document summarizes individual interviews and is sent to relevant interviewees for approval. The second one sums up the approved content and is distributed among the others participant who will attend the focus group collaboration meetings. In terms of the agenda planning, it was observed that the approximate time from the interview taking place to the approval took around 4 elapsed weeks. Hence, this has to be taken into account when drawing up schedules. It was challenging to keep the meetings of the focus group in the time constraints. Participants, from time to time happened to choose a topic for a discussion which was not strictly related to the scope of the meeting. These situations were handled diplomatically and the researcher role was to keep the time allotted in mind at all time. Finally, almost all participants had some slides already prepare prior to the interviews. Thus, the extra time for such unexpected circumstances has to be included in the agenda of the reference model.

The following section presents an overview of the result of the collaboration with practitioners phase in this design science research work. The outcome was modelled accordingly to the section 4.4, this is the ontology was created first and then used to model the business process model for measuring innovation value. The following section briefly summarizes the outcome of this case study.

Outcome: Measuring Innovation Value Process

The purpose of innovation is to create business value. That value can take many different forms, such as improvements to products, construction of new products and services, or reducing costs. In this case study it was found that it does not only matter how the innovation projects are managed but also which metrics are chosen to measure them [249].

The business process model for measuring innovation value consists of four main stages illustrated on Figure 5.6. Although the process is executed in an iterative manner, it is presented in a linear fashion to keep the description straightforward. In addition, the process can be ceased at any stage.

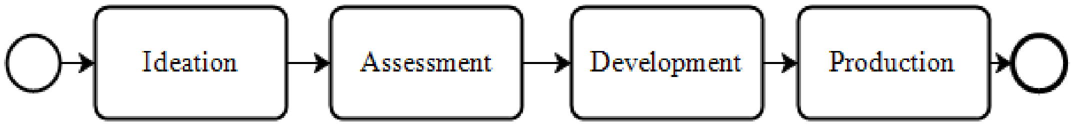

Figure 5.6 Top level of the business process model for measuring innovation value

The purpose of the *ideation* stage is to endeavour both to expose unknown and desired needs, and to develop new solutions that can meet those needs through which new market of possibilities can be uncovered. An observed practice is to engage with current and potential customers to receive feedback on specific concepts. During the collection of concepts and feedback, a set of objectives regarding concepts is acquired.

The *assessment* stage contains two main phases: (1) proposal assessment, and (2) final assessment. The former takes the concept of an innovation project and assesses its general rationale. It examines the project through criteria such as feasibility or alignment to business strategy. Those that pass this proposal assessment are moved to the final assessment. It applies criteria that assess potential business value of the innovation project.

In the *development* stage the innovation project transforms into a finished product. It requires the innovation originator to engage with relevant developers and testers. It engages interactions with potential customers and non-customers to see how they respond.

At the *production* stage, the product is being implemented into the business processes. Now, the organization can earn the financial return by successfully selling the new products or gaining benefits from improved efficiency and productivity.

5.5.2 Case Study on Migrating Business Models to the Cloud

The following case study describes the application of the reference model, introduced in chapter 4, in carrying out design science research for a business process model artefact. In the period of 6 months, a post-doctoral researcher student constructed a consolidated business process model of migration business models of small-medium enterprises to the Cloud. During the course of the research, the researcher took on the design science paradigm and followed the reference model.

The following first introduces the research motivation, problem and briefly findings of the literature review. Then, the course of collaboration with practitioners is described in detail. Finally, the outcome is presented.

The identification of a migration process problem started due to requirements of an industrial research project. The research project was supposed to develop an application hosting scenarios range from on-premise solutions to private and public clouds for small and medium enterprises. In this context it became evident that a consolidated process of migration business models to the Cloud was needed. Thus, the first idea for the research problem came from industry requirements.

Following the reference model, a systematic literature review was conducted to discover which cloud migration processes already existed. It was discovered that a considerable number of migration processes were available, but that the intelligibility of descriptions of the processes published varied substantially. Literature revealed that the Cloud computing business model is characterized in three layers, such as the infrastructure layer, the platform-as-a-service layer and the application layer on top [250]. Each of the layers provides a variety of opportunities and obstacles to the potential businesses solutions that wish to move to the Cloud. The obstacles are categorized to the ones that affect adoption, growth, and business policy [251]. The findings of the literature review enabled a level 1 diagram of the migration process. The operational activities had to be retrieved out of the practitioners involved. That was the collaboration with practitioners phase of the design research.

According to the reference model outlined in Figure 4.8, the first phase was to determine the scope of the collaboration. Thus, the analysis of the topics, the involved participants, and resources were conducted. The topic analysis was formulated as a process to perform migration of existing business models to the Cloud, including methodologies, technologies, and tools. The deliverables were to represent migration process modelled in BPMN. It was agreed that the process should identify and characterize business models with the regard of fitness to the Cloud. Decomposition of the level 1 diagram of the process into the level 2 along with each identified activity of the process to be accompanied with relevant tools was decided. Overall, seven participants were involved in the focus group collaboration. They were selected following Appendix 4. Finally, the resource analysis concerned the available time (2 hours for each individual interview), location (the university collaboration centre), channel of communication (verbal personal meetings), and technology (mind map software, participants wide availability did not require usage of online collaboration tools). The mind map software was used to gather, discuss and visualize insights provided by participants. Participants were with cloud engineering and IT consulting background.

The focus group collaboration followed the activities listed in Table 4.7 and selected methods from Table 4.9, outlined in the section 4.3.3. Upon defining the scope of the focus group and participants, the researcher prepared questions for the upcoming activities accordingly. In the step 0, the questions were split into two sections. First section was to understand and determine participant's connection to the migration process in detail. Thus, the questions were formed around their organizational units, daily activities, main responsibilities, and personal understanding of the migration process. The second section refers to the part of the migration process that individual participants have the most expertise, and could only be fully shaped upon the first section was answered. However, based on the findings from the literature, some expectations about the process and its activities were assumed to generate general questions about the process. For example, how you map business models to cloud products, what activities help to determine business models, how to execute cloud migration. These questions were later decomposed into more detail ones, once a participant's exact area of expertise was determined.

In the step 1, the interviews with each participant of the focus group were conducted. This phase was divided into two activities (B1-B2). In B1, the researcher focused on understanding a participant's expertise regarding the migration process. Hence, the researcher followed laddering interview method and only the first section of questions was asked. Answers were put and visualized on a mind map. The interviews lasted 40 minutes followed by a 30 minutes break. During the break the questions of section two (B2) were detailed accordingly to the participant's area of expertise. This part followed the semi-structured interview method. It lasted 45 minutes to shape the migration process according to the individual participant's perspective. The asked questions were to support the construction; and related to migration activities being elaborated, their key elements, input and output data, the order of the activities, and the performers.

In the step 2, all processes constructed at individual interviews were summarized with their specific context and distributed to all participants prior to the focus group meetings. One of the goals was to raise awareness how much others contributed and that at the focus group meetings, even more concrete information would be expected.

The following step 3 describes the focus group activities. The researcher began with an introduction of the agenda of the meeting followed by allocation of 5 minutes for each participant to introduce their organisation, roles, and relation to the migration process. This was a result of an ice breaker method to get to know each other better. The rest of the focus group meeting was structured accordingly to the KJ method. For next 30 minutes, the presentation of migration processes identified at each interview took place. During that time participants asked questions that could further clarify all possible misinterpretation of presented activities of the migration processes. That caused some activities to be renamed, reordered, or removed from the processes. Once everybody's contribution became clear, the researcher started working on building the consolidated migration process. First the participants were asked to identify and group similar activities. Participants, one by one, had 10 minutes with the processes to group activities in relation to their own beliefs. They were allowed to move activities to other groups and rename the groups allocated by their predecessors. Basically, when a participant reviewed the group of someone else, which did not make sense to them, they kept rearranging the activities until the grouping made sense. Then, copies of the final shape of the grouped activities were made and distributed to the participants. The following activity required from them to build the migration process using the predefined grouped activities only. The goal was to provide the order in which these groups of similar activities should be executed in the migration process. Then, if it was possible, the participants were asked to provide the right order of activities under each group. The ordering was done by assigning numbers to the groups and activities. Finally, the individually structured processes were discussed. At this last activity of step 3, the researcher presented all versions of the migration processes and began the attempt to consolidate them into one. First all groups and activities having the same order were linked together. Then, discussion about differences between groups that had been placed in different orders took place. The goal was to reach the order on which the majority of participants could agree. The researcher used mind map software to easily move groups and activities for the final consensus. The focus group meeting ended after 4 hours including 40 minutes break. For the step 4, the researcher organized a short 40 minutes conclusion meeting at which the consolidated process modelled in BPMN was presented.

Feedback received upon and observations made during this case study enabled a further refinement of the reference model. It was confirmed that participants are keen in taking part in workshop type activities. When the meeting of a focus group is facilitated in a friendly atmosphere much more information is revealed. Therefore, the ice breaker activities cannot be left out. As some information can be treated as off the record, the researcher must make sure not to use it in the further analysis and adequately outline the sensitive data. Thus, additional activities to approve the information carried out in the further phases of the reference model should be implemented. Another interesting finding was not to disclose all questions previously prepared. This enabled for open-minded discussion and did not drive in a particular direction the shape of the business process model investigated. In terms of constructing the questions, the following approach was recommended: questions should trigger a line of thought to suit the headings for discussions.

The following section briefly outlines the outcome of the collaboration with practitioners phase in this design science research work. This is the consolidated migration process of business models to the Cloud.

Outcome: The Migration Process

Migration business models to the Cloud can be understood and approached from various angles. According to the Cloud Business Model Framework [250], the following migration process considers the migration at the *platforms in the Cloud* layer. The migration process focuses on development of cloud applications for the migrated business models by the Cloud provider. From this perspective the process is described. At the high level the migration process consists of three activities, which are carried out in an iterative manner: Plan, Development, and Deployment

The main goal of the *plan* phase is to understand the business model and determine if the Cloud make sense to the business and what impact the Cloud may have on it. This is usually carried out by business analysts and industry experts. Their work covers three stages: assessment, analysis and planning of the process migration. This is to get the deep knowledge about the way the business operates and how the business works. The planning stage can be viewed from two perspectives: success criteria and capability. The success criteria define what a successful migration looks like, while the capability defines what the technical requirements are for a successful migration.

At the *development* phase the web-based applications for the business are developed. The Cloud provider responsible for delivering the migration looks after acquisition, installation, and configuration of any hardware and software necessary to get the business to the Cloud. During the development, varieties of tests are performed, such as functionality, unit testing, and user scenarios. Since the development happens as the business operates, new requirements may emerge at any point, hence the Cloud provider usually applies agile methodology. Figure 5.7 illustrates the development process.

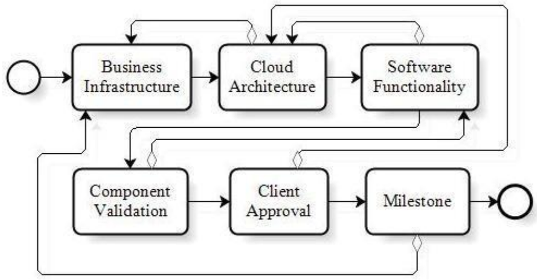

Figure 5.7 Development phase [252]

The *Deployment* phase refers to the act when the Cloud application is ready to be plugged into the business (e.g. the business database). There are three main aspects to be considered here: a backup of data, documentation of the migration, and specification of the Cloud component plugged. The data backup is to avoid a risk of losing any data in case of the deployment failure. The Cloud provider usually implements a backup functionality in the Cloud application. The aim of the documentation is to highlight what worked, what failed and the lessons learned during the migration. The specification of the Cloud component underlines what business aspects are covered and are usually checked against the migration requirements stated by the business at the plan phase.

5.5.3 Case Study on Assessing Data Quality in Service Oriented Architectures

The following case study describes the application of the reference model in design science research. First it outlines the research motivation and questions. Then, it presents the execution of the systematic literature review process and derived results. The aim was to underline the literature review perspective to the research problem. This project showed sufficient complexity and was complementary to the other case studies demonstrated.

In the period of 8 months, a PhD research student investigated data quality in the context of Service oriented Architecture (SoA) in academic and professional literature. All findings and outcome presented in this section belong to him and have already been published [253]. This section demonstrates the application of the reference model to his undergoing design science research. The research motivation emerged from the fact that SoA is a promising approach that offers the business a flexible and agile way of integration new services and thus improve the dynamic of the business process. Owing to the SoA key principles such as reusability, interoperability, and standardization, enterprises can benefit by reducing the costs of operation and maintenance, less time for applying new services, and more agile service management [254]. However, in more complex architectures orchestrating the services are difficult to handle [253]. It becomes challenging to manage such architectures without having the awareness of the data, processes and events running within the enterprise environment. To support the process of orchestrating, as well as development and evolving progress, a data monitoring techniques must be integrated [255]. Hence, this research followed the design science approach to assess data within service oriented environment.

The research objectives were to discover a process that will facilitate detecting poor information. Following the found materials document (see Appendix 3) recommended by the reference model two main research objectives were stated: definition of poor data and detection of viral data within SoA. Following activity in section 4.2 a systematic literature review was conducted. In the *"select studies for detailed evaluation"* phase closer attention was paid to publications, special issues, and specialist conferences that explicitly emphasized on the keywords 'define' and 'detect' poor data. As the research progressed, it was identified that from informational quality point of view the term 'detecting' was comprised in the term 'defining'. That suggested that before *detecting* poor data it must be *defined* first. Poor data was assumed as contradiction of quality data. Based on these statements and collected references about poor data, its definition was stated. From information technology point of view, poor data can be any data which does not satisfiy business requirements of its intend and thus fail to deliver enterprices expected results. As the research moved into the *"select activities from studies"* literature review phase, a few approaches were identified. Some studies indicated data ontology analysis [256], direct database analyses by using trust tables [257], or relying on applying business rules [258]. Upon applying inclusion and exclusion criteria of the research the business rule approach was selected. It was justified by reasoning that this approach allows assessing data more objectively than the other approaches since it enables the business ultimately define the data in the context it is used. As one of the definitions of data quality states: "Business ultimately defines data quality". Hence, the activities for the business process model were derived following the general perception of data quality management (DQM) [259]. From the literature review four main stages in data quality cycle were identified - Quality Assessment, Quality Design, Quality Transformation and Quality Monitoring. This delivered a valuable direction of the overall process of data assessment and monitoring. Hence, the researcher followed this cycle paying particular attention to the core elements of detecting poor information within service environment.

By identifying activities coming from data quality management, business rule approach, standards and specifications such as Business Process Execution Language (BPEL), Web Service Description Language (WSDL) and Simple Object Assess Protocol (SOAP) involved in SoA, the researcher moved into modelling phase of the research. That was to get the business process model for assessment data quality in SoA. First the ontology of all these terms was prepared. It gave the researcher an overview of all findings and clarification of terms to be used. Having the knowledge base, the business process model was constructed.

Feedback received upon and observations made during this case study enabled a further refinement of the reference model. Key activities of the business process model were added to a mind map as the research progressed. Having them under the predefined topics enabled the researcher to spot black boxes and topics not yet fully investigated. The corresponding found materials document stored all the references and description of the activities retrieved. It was pointed out that decision on selecting the next topic, for which to search was based on, was the mind map. As the research evolved, it was noticed that a slide to explain the research project and the current shape of the business process model artefact helped in the communication between the researcher and the stakeholders. The most challenging part of the literature review was to decide when to stop the search and move to the modelling activities. The researcher made this move when there was no new activity for a certain topic in the available literature and the other activities found showed some connections to each other or certain gaps were justified in the literature. The other factor to stop searching for a certain activities was due to the time constraint of this research work. Finally, the literature review demonstrated that having the initial shape of the artefact does not cause any difficulties in defining the profile for desired practitioners to collaborate. The following section briefly outlines the outcome of this case study.

Outcome: The Assessment Data in SoA Process

The process of assessing monitoring data consists of four main phase – preparation, pre-execution, execution, and analysis. The BPMN Diagram on Figure 5.8 depicts overview of the process of data quality assessment in service composed environment. In the next few paragraphs, each phase is described.

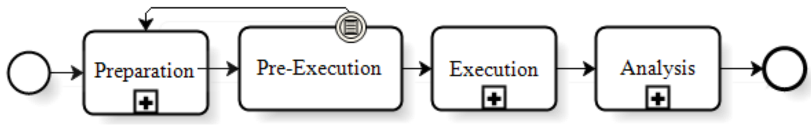

Figure 5.8. Data Quality Assessment Process in SoA [253]

The *Preparation* phase is where the quality is described following data quality management (DQM), thus it can be perceived as quality design phase. In this phase a business person chooses a process and defines a business rule or set of rules that apply to it. In this way, an enterprise explicitly defines the quality of the information required. The business process selected is undergone series of analysis, which scan the file and search for BPML attributes that correspond to the metadata that need to be collected. Then a list of services along with their data/read functions is presented to the user. Next the business administrator/architect composes the rules using business rule approach, and store in an external repository.

The aim of the *Pre-execution* phase is assurance. Assurance in this context means that monitoring rules that were composed by applying the preparation process will be inspected for outdated information. The process of inspection consists of opening the rule repository, then reading the rules and compares the variables according the business processes mapped to them. If an out-dated rule is detected, the business body will be referred to that rule and accordingly to the stage of building monitoring rules, part of preparation stage. This phase is executed every time before the rules are being executed. In this way it prevents faulty detections.

The *Execution* phase is the stage where the business quality defined applies to the data. More specifically, in this case, the quality defined is handled by following the process of composing monitoring rules described in previous paragraphs. It contains activity such as reading rules from repository and building SOAP enquiries, and generating a log. The log is the output of this phase.

The *Analysis* phase involves generating problem-cause reports in accordance to the user preference – e.g. generating report with the names of the ‘faulty services’ or ‘number of the mismatched rules’. In any way, in order to generate such reports a services’ log must be read first. Ultimately the analysing stage aims to evaluate the whole process of detecting viral data.

5.6 Discussion

In design science research, the design artefact and its successfully met objectives are the central components [7]. In this research, there were five objectives stated which shaped and influenced the research work (see section 1.4). The *ease of understanding* objective was extended to representational information quality and thoroughly examined in the deployment evaluation perspective. That was by conducting experiments to measure how well the information provided by reference model was perceived by its users and stakeholders. Embedded *academia and best practices* in the reference model were illustrated in chapter 4 and their application was observed throughout all evaluation perspectives in chapter 5. An important evaluation perspective of the reference model artefact was its application to design science research problems. The examined case studies, experiments and design theory of the artefact, showed its *feasibility* and the research settings in which the feasibility objective can be achieved. The studies were chosen because they represented examples of design science research with various requirements for information sources as the reference model has to offer. Moreover, by building various business process model artefacts the *type of data* objective was met. The reference model does guide design science researchers in development of business process models without imposing specific instances of data, thus the model is suitable for various business process model problems in design science research. Finally, the *technology free* objective, it is possible to follow the reference model without use of any technological aspects. Simply a pencil and piece of paper can be addressed. However, there are technological solutions that can increase time and research performance. Although the best features are usually costly, some tools were indicated, in Table 4.10, with which free execution of the reference model can be conducted. Table 5.11 illustrates and summarizes how the evaluation presented above refers to the objectives of the reference model.

Table 5.11 The juxtaposition of evaluation perspectives and research objectives

	Objectives of the reference model				
Perspective	*Technology free*	*Types of data*	*Best practice & academia*	*Feasible*	*Ease of understanding*
Epistemological		●	●	●	
Economic	●		●	●	●
Deployment	●	●	●	●	●
Engineering	●	●	●	●	●

By incorporating insights from practitioners in the design science domain and studied relevant literature, a first version of the reference model was created. It was then iteratively applied in a series of trials in form of case studies and experiments, as outlined in sections 5.4 and 5.5. A number of participants were using the model while observations and feedback were gained. Through these trials, a continuous enhancement was made, resulting in a more refined reference model. Several key observations have to be considered concerning the reference model.

When the literature review as a source of information was used, duplicated papers and inconsistent evaluation of extracted activities caused some research distractions. There were number of papers reporting similar findings based on the same design science projects and data sample. Upon further investigation, it was identified that the various papers were actually duplicated reports. Mostly duplicates were coming from different digital libraries. Some duplicates were among the additional materials that were collected by following leads from references. One of the main causes of not detecting these duplicates relied on the fact that materials had different titles and were published under different publishers. It was not possible to find a duplicate until the material reached the reading phase of the literature review. When process activities extracted from the literature are being checked by a stakeholder, it is important to ensure that the stakeholder understands the meaning of the activities. In some cases the stakeholders only checked the figures of the extracted activities and made their opinions rather than reading their descriptions, which would have clarified many of the follow-up ambiguities.

When the collaboration with practitioners as a source of information was used the key observations were drawn on interviews and group meetings. At the outset of interviews, practitioners insisted to give presentations of their companies. However, such presentations could hardly be taken into account prior to the interviews and their lengths are difficult to establish. Nonetheless, researchers should appreciate any work that their interviewees prepared prior to the interview, and use it in a way that it does not interfere with the agenda and questions. Moreover, one must be careful not to offend the interviewee, leading to lower level of engagement. As interview agenda contains 10/15 minutes for introduction, any ad hoc presentation should be accommodated within this time. As observed in case studies in section 5.5, 1 hour for an interview was a bit in hurry, thus if it is possible more time each section of the interview should be introduced to enable more in depth conversation. Although, the ultimate goal is to carry out an interview according to the agenda, the interviewee's answers do not always comply with that intention. Thus, it has to be balanced between sticking to the agenda and not offending the interviewee. If the interviewee's answers are getting off the track it is advised to diplomatically navigate back to the core of the interest. Keeping focus of the interview on the right track is still challenging, since practitioner's experience varies, which weight some aspects at the expenses of others. A slide to explain the research project and their role therein at the outset of the interview underlines the importance of the interviews and encourage the interviewee to reveal more relevant information. Similarly, keeping the participant meetings in the time constraints is still challenging. Participants like to pick up a topic which is not strictly related to the scope of a session. This has to be handled diplomatically. The researcher role is to keep the time allotted in mind at all time. It is possible and fully feasible to hold such meetings in online environments; however, a relatively good bandwidth and video camera must be on both sides. In addition, tools as the one listed in Table 4.10 allow each participant to record and share thoughts as they arise. It was found that practitioners are keen in taking part in workshop type activities and play with the new technological gadgets. When the focus group collaboration is facilitated in a friendly atmosphere much more information is revealed. However, some information might have to be treated as off the record and should not be used for further analysis. The following section presents which activities can be inferred from the reference model and applied not only to business process models but also to other types of design science artefacts.

5.6.1 Activities Inferred for the Meta-Design Phase

Taking into account the points of views of all evaluation perspectives and the observations, adaptability of the reference model to individual design science research requirements in a safe and convenient way is the core challenge. Researchers indicate that a key notion to accomplish it is *abstraction* [24]. In relation to the reference model, this is demonstrated with constant parts of the model and those parts that are subject to change and adaptation. These parts can be reflected in the architecture of the model (e.g. constant parts – collaboration with practitioners, variant parts – conducting focus group collaboration). Moreover, changing variant parts should not cause any side effects on other parts of the model (e.g. each case study executed gathering information differently but adequately to their research needs and still were able to successfully model their artefacts).

Abstraction can be fostered by applying *classes* and *generalisation*. The idea behind the class is to enable abstraction from single instances. The single instances of the reference model are the ways of which the model was executed. Hence, the reference model reflects the class abstraction. As a result, changes made in the reference model can be visible to all instances at one place. Generalisation enables abstraction of special features of the class abstraction. Features that are constant parts of the class abstraction can be drawn and transparently affect other class abstractions. This means that certain features of the reference model can be drawn and adapted to other types of design science artefacts else than the business process models. This enables for adapting implementation of the needs of the other reference models without changing the default interface. Thus, to achieve the generalization of this research artefact, this research work goes beyond the business process model artefacts and draw general activities for the meta-design phase of design science research methodology. Chapter 2 outlined types of activities that design science literature found crucial for the meta-design phase, but it did not provide their order and guidelines to which design science researchers could refer. The construction of the reference model and its application enabled to outline the order of activities for the meta-design phase and provide general characteristics for each of them. This was to allow adaptation of some capabilities of the reference model to the need of construction other design science artefacts. The result is a process model consisting of six activities in a nominal sequence whose justification is emerging from the reference model. With a focus on possible improvements in design science research methodology that might proceed from the use of the reference model, evidence has been developed for its six activities and their probable success as a methodology in a future research study. By incorporating insights from the reference model and observations in a particular domain, these six activities were identified. These activities are presented in Figure 5.9 and described below.

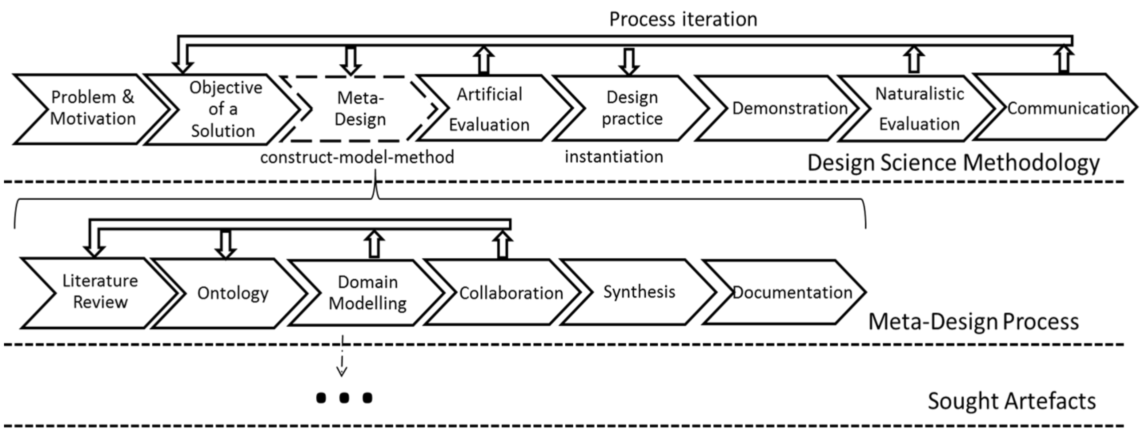

Figure 5.9 The Six activities of the meta-design phase.

A methodological review of past *literature* is a crucial endeavour for any research work [42]. The importance of an effective literature review is in ensuring that the researcher demonstrates a full understanding of the body of knowledge related to the phenomenon under study [45]. Hence, regardless of what design artefact is under investigation researchers should consider existing reviews and the assessed volumes of potentially relevant studies, various combinations of search terms derived from the objectives of a solution phase, and checking trial research strings against lists of already known primary studies. Moreover, the literature review should be documented in sufficient way that the readers are able to assess the thoroughness of the search. Changes and justification should be applied as the search occurs. It all should be saved and retained for possible reanalysis.

A way to save and retain information gathered from any source of information (e.g. literature, experts), can be addressed by constructing *ontology*. It can be expressed by conceptual frameworks for modelling domain knowledge; content-specific protocols for communication among inter-operating agents; and agreements about the representation of particular domain theories. In the knowledge sharing context, ontologies are specified in the form of definitions of representational vocabulary. Having constructed the ontology, researchers can access the rationale of built knowledge base, kernel conceptualization of the world of interest, semantic constraints of concepts together with sophisticated theories and technologies enabling accumulation of knowledge which is dispensable for knowledge processing in the real world.

Having the knowledge base provided by ontology, design science researcher can transform it into a desired artefact. Due to the variety of possible domain under investigation, it is not possible to suggest or favour any specific *modelling* language. This is a project specific matter, which at many occasions is stated in the objectives of the investigated artefact. This work outlined top-bottom approach in modelling an artefact; however, bottom-top can also be applied. The key point is not to omit any of the functional areas of interest. The ultimate goal should be to receive a series of diagrams that represent the desired artefact in a way that is clear and easy to communicate.

Collaboration is another way of gathering information for the desired artefact. Its focus is to obtain best practices from the domain experts. The experts should be recruited and selected based upon predefined characteristics. Asking the right questions or providing the right instruction to the experts is one of the most vital phases in collaboration. The questions and instructions should not be too complex, ensuring that the outcomes generated can be used for further analysis. There are varieties of methods that can help facilitate collaboration, e.g. focus groups, interviews. In selection of a right method for particular collaboration, researchers should consider if the method enables experts to react to each other and draw conclusions about contrasts or similarities in the collective opinions across experts as well as the depth of dissenting opinions.

Synthesis involves collating and summarising knowledge about the investigated artefact and models of the artefact built on the different source of information. The goal is to identify patterns among sources examined, or other interesting relationships that may come to light in the context of the desired artefact. Depending on the type of the artefact the synthesis can be achieved with quantitative methods such as meta-analysis, or qualitative ones such as meta-ethnography. The former assesses a common measure of effect size, of which a weighted average might be the output of a meta-analysis. The weighting might be related to sample sizes within the individual approach to the artefact. The latter tabulates in a manner consistent with the domain problem [67]. Tables are structured to highlight similarities and differences between models. The task there is to integrate models comprising natural language results and conclusions, where different models may use terms and concepts with subtly different meanings.

The final *documentation* of the desired artefact requires describing the research outcome circulating the results to potentially interested parties. This includes the research supervisors, practitioners involved in collaboration or designers for the design practice phase. The structure and contents of the artefact description depends on the domain and requirements stated in the earlier phase of design science research. The outcome of the activity is a fully descriptive documentation of the artefact, which then can be moved to the design practice phase.

Both activities for meta-design phase and their instantiations in form of the reference model promote more structure in the research process for the general research requirements and construction of the desired artefact by expressly using declarative logic and combined best research practices. This added structure enables design science researchers to discover more alternative components for the specific artefact. The overall potential of improvements in structuring meta-design phase, enumerated in this work, provide a positive indication of the potential value of design science research approach. On the basis of the evidence in this work, future research is encourage for development design science artefacts following the more structured design science methodology. There was no generally accepted framework for conducting and presenting design science research until the design science research methodology framework proposed by Peffers [7]. This framework gave a high level shape and provided characteristics of design science research process. Afterwards, other high level design science research frameworks were proposed [9]. This work provided activities for meta-design phase that appeared in most proposed design science research methodologies, as discussed in the section 2.2. The primary data was used in the form of three case studies and two experiments, to demonstrate the application of the reference model. Results of the analysis of the cases and experiments showed that general activities of the reference model can be well framed in terms of the meta-design phase of the design science research methodology. Thus, this discussion was used as a vehicle not only to evaluate the reference model but also to transfer established general meta-design activities into a formal research process framework. Without a well-defined and structured process framework that is commonly shared by IS researchers, reviewers, and editors, design science research moves towards the risk of being mistaken for poor-quality empirical research.

5.7 Summary

In this chapter the research artefact - the reference model was evaluated by means of application to the Multi-Perspective Framework for Evaluation Reference Models. This required examining the artefact from four perspectives. The Economic perspective aimed at discussing criteria that were relevant for judging costs and benefits related to the use of the reference model. The Epistemological perspective focused on criteria for evaluating the artefact as the result of scientific research. Hence, the model was assessed according to seven components of an Information Systems design theory. The Deployment perspective focused on criteria that were relevant for those who work with the artefact. Two experiments concerning improvement of perceived representational information quality between involvement of the process orientated reference model in design science research and its absence were presented. The Engineering perspective aimed at evaluating the reference model as a design artefact that has to satisfy its specifications. The main specification concerned there was feasibility expressed in three case studies. Nonetheless, all five research objectives were assessed in those perspectives, summarized in the discussion section. That section outlined which general research activities were drawn from the reference model to satisfy the meta-design phase for artefacts of other types than only business process models.

Chapter six outlines a review of this research, including its position, contribution, and limitations. It recapitulates the research themes and outlines some possibilities for future research.

6 Conclusions

6.1 Introduction

This chapter outlines the conclusions of this research work and critical review. First, it positions the contribution of this design science research work. It presents the nature of the reference model artefact and its implications for design science research methodology. This refers to the state of the field of knowledge and the audience to whom it is to be communicated. Then, it elaborates of significance of the work in the context of the three research themes and research questions contained. A critical review of the limitations of the methods chosen and the artefact are outlined. Finally, this chapter discusses the possibilities of future research, including a number of directions for design science research methodology.

This research involved a variety of approaches to the problem of structuring design science research methodology; interviews, focus groups, and systematic literature review. It identified that meta-design phase of this methodology is still on high-level of abstraction and provides lack of specificity. In addition its application is insufficiently clear and inadequately operationalized [9,7]. By focusing on a specific artefact domain, the business process model, the necessary activities for business process model artefacts were identified. From them general activities for meta-design phase were drawn. It is within this context this research was conducted. The mixture of quantitative and qualitative methods enabled to carry out the research questions both experimentally and by practical application thus improving its rigour. Moreover, this research used existing frameworks and measurement instruments, previously tested for rigour and validation [67,189].

6.2 Position of the Research

A design science artefact can be perceived through different types and levels of research contributions. This may depend on the starting point of the design science project in terms of problem and solution maturity. This examines the advancement in knowledge in terms of the characteristics of a well-developed body of knowledge [86]. The variations between problem and solution maturity reflect the placement of the research along the timeline of knowledge growth in the discipline. This determines relevant problems and solutions available to design science research project. Figure 6.1 presents a matrix of a research project contexts and potential design science research contributions [260]. This research falls within the scope of the exaptation quadrant, highlighted by a circle.

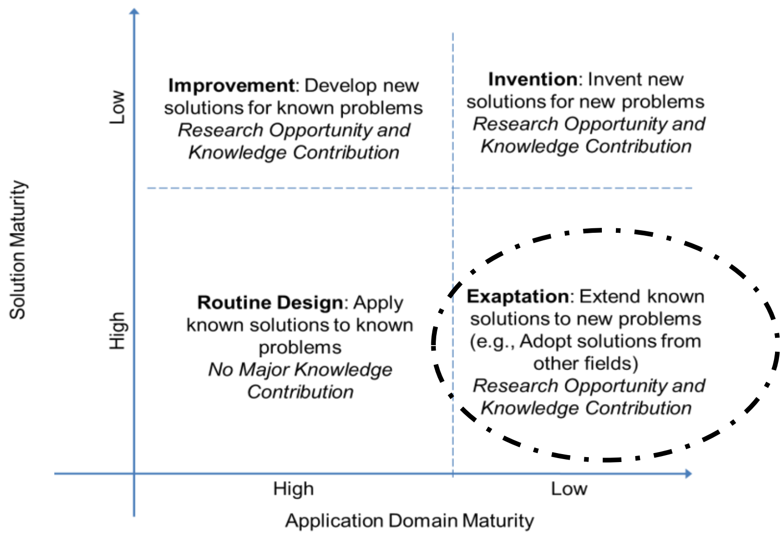

Figure 6.1 DSR Knowledge Contribution Framework [260]

Exaptation refers to contribution where design knowledge that already exists in one field is extended or refined so that it is extendable to some new application area. In other words, artefacts may exist in related problem areas that may be adapted or, more accurately, exapted to the new problem context [260]. This research work applied artefacts from other disciplines, such as computer science, social sciences, information systems, to solve research problems at the intersection of information technology and organization. Thus, the reference model artefact was produced by comparing and synthesizing multiple plausible models of reality which were essential for developing reliable scientific knowledge. That is to say, the reference model is a synthesis of research best practices that ultimately provided research activities for meta-design phase in design science research methodology. At the operational level, the reference model guides design science researchers seeking for business process model artefacts.

6.3 Summary of Contribution

The main contribution of this research work focus on three facets: building and evaluating the reference model by applying research themes, constituting activities for meta-design phase, and demonstrating a successful application of design science research. These contributions add to the knowledge and implementation of design science methodology, business process model frameworks in design science settings, and research evaluation. This research work was shaped along a number of research themes which helped in formulation of specific research questions and were aligned to the research design (section 3.7). Below, it is outlined what research questions were addressed in each research theme.

6.3.1 Research Theme - Construction

The scope of this theme was to answer two research questions regarding design and development of the artefacts in meta-design phase of design science research methodology. It was assumed that by developing a reference model that would focus on a specific artefact of interest (e.g. a business process model), research activities to detail meta-design phase would be determined. The two following questions were stated to help construct the reference model for business process model artefacts in design science:

1. *How to consolidate different views of the meta-design phase to build the reference model?*
2. *How to systematically approach construction of business process model artefacts?*

Design science literature review outlined three core high level activities: literature, collaboration, and modelling that should be undertaken in constructing any design science artefact for the purpose of the meta-design phase. However, no further operational guidelines how to approach these activities were provided. On the other hand, design science literature indicated that is possible to construct an artefact starting from its construct layer and gradually reaching towards the method layers through its model layer. Having established these core activities and layers, a conceptual framework was proposed. It was used to construct the reference model artefact. The reference model is ultimately a significant expansion and more structured form of the conceptual framework with the focus on business process model artefacts. Once the reference model was built, it provided the answer to the second question on how to build a business process model artefact in the meta-design phase while conducting design science research.

6.3.2 Research Theme - Quality

The scope of this theme was to answer two research questions regarding representational information quality of the reference model and its outcomes. Quality of the reference model artefact is perceived through design science researchers and its outcome is assessed by stakeholders of the business process model artefacts investigated. Selection of the representational aspect of information quality emerged from one of the research requirements, the ease of understanding and its derivatives. To examine quality of the content of the reference model from the perspective of perceived information quality, the following questions were asked:

1. *How the information quality representation of the reference model can be determined?*
2. *What is the information quality representation of the reference model and its outcomes?*

To address the research questions experimental designs were carried out, as outlined in the section 5.4 and examined representational information quality with its dimensions for the purpose of the experiments in the section 2.5.1. Regarding the first experiment, it examined the improvement of the perceived representational information quality between design science research guideline accompanied with the reference model and the general design science research guideline. The dependent variable was the total scores of design science researchers rating of the representational information quality of research guideline. In terms of measurement, the 11-point Likert type scale questionnaire on representational information quality dimensions was used. The results of the experiment, described in section 5.4, indicated that the reference model explains 10% of the total variability in total scores of the quality of the represented information provided to design science researchers. Regarding the second experiment it examined the improvement of the perceived representational information quality between business process model artefacts developed with and without the reference model in design science settings. The dependent variable was the total scores of practitioners rating of the representational information quality of business process model artefacts. In terms of measurement the same questionnaire like in the former experiment was used. The results indicated that the reference model explains 35% of the total variability in total scores of the representational information quality of business process model artefacts.

6.3.3 Research Theme – Impact

The scope of this theme was to demonstrate what impact has the reference model on the design science paradigm and how well it meets its business and research requirements. Design science artefacts have the potential to provide important and valuable contribution to its relevant discipline. The following questions were asked:

1. *How to examine theory developed by the reference model in design science settings*?
2. *How the outcomes of the business process model artefacts meet research objectives?*

To address the first question, components of the reference model were examined to define the theory it provides. The model was analysed from various perspectives such as utility to a community of users, the novelty of the artefact, and the persuasiveness of claims that it is effective. In the result, the seven structural components of theory were applied to present the full specification of the design theory for business process model artefacts in design science, as discussed in the section 5.3.

The second question, which refers to the capability of the reference model as a process artefact and its outcomes to meet research objectives, was examined in the evaluation section. The ease of understanding objective was extended to representational information quality dimension and measured in experimental designs (section 5.4). In addition the ease of understanding was observed during case studies. The academia and best practices objective was met by embedding these features in the construction of the reference model (chapter 4). Its importance was indicated throughout all evaluation perspectives. The introduced case studies, experiments and design theory of the artefact demonstrated its feasibility and the research settings in which the feasibility objective can be achieved. Moreover, by building various business process model artefacts the type of data objective was outlined. The reference model does guide design science researchers in development of business process models without imposing specific instances of data, thus the model is suitable for various business process model problems in design science research. The sections 5.4 and 5.5 outlined that it was possible to follow the reference model without incurring the costs associated with technology.

Development of the reference model was followed by the design science methodology and by meeting business requirements from the research questions; it was possible to demonstrate the utility of this approach. Hence, this research work concludes the legitimacy of the reference model artefact by meeting its requirements substantially.

It also generalized the legitimate reference model artefact to fit for use of design science researchers in the meta-design phase of design science research methodology. That is to say, it fulfilled the main research motivation regarding the lack of specificity for the meta-design phase.

6.4 Research Limitations

Several limitations have to be considered concerning the results of this research work. First, the reference model artefact is meant to be followed by a single design science researcher conducting design science research on a particular business process model artefact. Although, it is possible to split the research work in a way that researchers can follow the reference model in collaboration, all the results and findings outlined in this research work were based on a single usage of the artefact.

One aspect of this research was to investigate the impact of the reference model on the perception of the representational information quality. To address it, experiments with research students and practitioners were conducted. Due to the fact that design science research requires significant amount of time and access to data, the experiment with research student was limited to 3 months and only two practitioners were available for that time period. In addition, students participating in the experiment came from different cultural backgrounds, high-school programs, and motivation. However, none of the students had followed other courses that addressed the design or facilitation of design science research work. In the experiment with practitioners, they had to conduct a limited set of tasks appropriate to research objectives. Evaluating a full spectrum of quality of business process model artefacts was beyond scope of this research. A longitudinal study of developed business process model artefacts with the reference model would enable to conduct a more in-depth analysis of researchers' roles including such factors as research experience, use of technology, and required supervision. However the experiments did demonstrate that the reference model had positive impact on the perception of representational information quality of design science research methodology and its outcomes.

Another limitation of this research work is the focus on only one of four possible design science research entry points, *the identify problem and motivation* phase [7]. Hence, the reference model was built and evaluated concerning only this entry point. When the reference model is carried out by the researchers who are entering design science research from other points, they might bring a biased view towards the fitness for use of the reference model. However, a modular nature of the model can be observed where certain activities can be omitted to accommodate design science research requirements.

The case studies demonstrated covered key aspects of the reference model in sufficient details. Thus, that the evaluation was done to a reasonable effort to validate the reference model. At the expenses of the literature review part, in the case studies, the effort was put on the collaboration with practitioners aspects of design science research to demonstrate its flexibility in selection of tools and activities. In addition, the time constraints around the case studies did not allow for more iteration in collecting data and designing the artefacts in questions.

From the methodology perspective, in the measurement of representational information quality, a questionnaire based on information quality dimension was used. A problem with a questionnaire relies on the respondents accurately reflecting their viewpoints and how these reflect the real world. Based on previous work on representational information quality [109], this research study moderates this limitation by adopting the validated questionnaire and providing its reliability and validity analysis

Finally, it cannot be claimed that the current version of the reference model for business process model artefacts represents a stable, final version. For this purpose, more design science research projects are required. For example, the model could be used with design science research experts rather than with novice designers such as the students. The identified six activities of the meta-design phase should be applied to a variety of design science research focusing on artefacts other than business process models.

6.5 Future work

Based on the research findings and limitations, a number of directions for future research on the reference model and the meta-design phase of the design science research methodology can be proposed. First, it would be beneficial to keep track and update the documentation of methods and tools associated with facilitating focus group collaboration, with the explicit description of alternative tools for each method and how methods can be reorganized to fit research needs.

Second, more research is required to explore which operational activities of the reference model can only be applied to build business process model artefacts and which can be used to build other process models that are industry specific or other types of design science artefacts in general.

Other efforts could be made to develop an instantiation layer artefact of the reference model that would support and automate its activities. This would be the design practice phase of design science research methodology. Such instantiation in form of a computer application could support the automatic generation and facilitation of research forms such as initial research scope, found research materials, or focus group agenda. In addition, it could navigate design science researchers through all the activities to be undertaken in research and provide description for each phase. A blueprint of the reference model for such instantiation can be found in Appendix 8. Moreover, this instantiation would help in designing a set of methods for focus group collaboration and integrate with relevant tools for more comprehensive collaboration needs. Further, given the prescription of capabilities within the reference model, it should be possible to create an interface for a specific design science research project.

During this research, it was found that there is little guideline in the design science literature about the choice of strategies and methods for evaluation design science artefacts. The most cited guide selection of evaluation strategies for design science projects consider the artificial and naturalistic framework [61] further extended by Venable [184]. Researchers pointed out that evaluation design science artefacts needs to decide what, how and when will be evaluated. However, this framework is not a framework for evaluating design science artefacts as a whole, but it only aids researchers in the design of the evaluation component of their design science research projects. Hence, beyond providing the framework and an idea of what needs to be built in the design science component of research, there is very little guideline in how a researcher should or could actually conduct the evaluation in design science research. This state of affairs in design science research constitutes what researchers call "a gap of practical evaluation strategies" [184], and this area requires more attention in design science research field.

It would be interesting to see an extension of the six identified activities for the meta-design phase which would inform a design science researcher about possible activities to undertake depending on the investigated artefacts. To validate such a research guideline, a number of design science research projects should be carried out in a variety of artefacts. In addition, it would be worth investigating whether sufficient design science guidelines are included that support a group of artefacts where group commitment is an important outcome.

Design science becomes more widely accepted as employed research methodology in IS field. The findings of this research work along with the reference model artefact provide a means for enhancing this methodology. This research provides the additional structures, methods, activities, and phases that are compulsory in conducting design science research in these ever demanding projects in information systems field.

7 Appendices

Appendix 1

Authors	*Framework*	*The construction phase*	*Case studies/ example of usage*	*Undertaken activities*
March [53]; Lahrmann (case study) [66]	A research framework	Build	Construction of maturity models	Literature review for the methodical foundations as well as theoretical considerations
Hevner [8]	DS Research guidelines	Design as a research process	Group Decision Support Systems	Discussions with stakeholders
			eXchangeable Routing Language (XRL)	Analysis of business process requirements
			Design theory to support emergent knowledge processes	Interventions occurred over a period of 18 months within the companies
Vaishnavi [23]	Design Science Cycle	Development	A support system for procedure driven environment.	The construction involved the "discovery" through multiple thought and paper trials.
Peffers [7]	DS Research Methodology Process Model	Design & Development	The CATCH data warehouse	The researchers drew from data warehousing research to develop the CATCH data warehouse.
			A software reuse measure	The concept of the reuse rate was obtained from software reuse literature, which served as the theoretical foundation for the development of the reuse metric.
			SIP-based voice- and video-over IP software	The software required participation from several European and other international participants. The software was developed, based on computer science and networking literature.
			A method to generate ideas for new applications that customers value	They incorporated an ideation workshop, where business and technical expertise was brought to bear on the task of developing feasible ideas for new business applications from the graphical presented preferences and reasoning of the subjects.
Offerman [34]	DS Research Process	Design Solution	A method and tool to service-oriented architecture (SOA)	Before starting to design the SOAM, all existing methods were studied in depth and compared. Additionally, best practices in method documentation were collected.
			Method for business rules extractions	Searching for a method in the literature - Before starting to design a method for business rules extraction and identification (BRM), existing methods and approaches were studied in depth and compared.
Alturki [9]	DS Research Roadmap	Develop (construction)/ and/ Define requirements	Design theory nexus	Building this solution "required a survey of existing literature and finding."
			Developing design science road map	The authors identified a set of articles which included most if not all attempts about DS methodology

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Baskerville [6]	Soft DS Research	Declarative search for specific solution	Diffusion and adoption of IT	Literature on diffusion and adoption of IT was brought in, and different authors who had analyzed various elements of the issue inspired the specific solution.
Carlsson [4]	Socio-technical IS design theory development	Review extant theories, knowledge and data / and/ propose/refine design theory and knowledge	Governance and management of IS integration in Merger &Acquisition	They surveyed existing literature on how to conduct realistic reviews to make sense of a heterogeneous body of literature. Workshops with stakeholders.
Sein [55]	Action Design Research Method	Theory Ingrained-Artefact / and/Building, Intervention, and Evaluation	Competency management system	Focus group discussions, participant observation, technology review, workshop sessions, semi-structured interviews, and attempts to adapt existing technology.

Appendices

Appendix 2

the Initial Research Scope

State the Research Project Title

Measuring Innovation Value

Identify the purpose, input, output, and main area of the research for the process

Why do you want to develop the .... ? (e.g. a process to help manage collaboration)

A capability model for measuring the value of Innovation realized by a firm (or subsidiary organization within a firm)

What should it do? (e.g. shows how to capture expertise)

It will provide a firm or a subsidiary organization within a firm with the means to develop a capability to measure Innovation value realised by the firm or subsidiary organization

What would be the output of it? (e.g. synthesized expert's knowledge)

It will guide senior management through the innovation process and indicate the points where the value of on-going innovation project can be measured.

What would be the input to it? (e.g. theoretical body of knowledge)

The process is embedded in the innovation project and the inputs would be any data that is carried along the innovation process.

Identify topics, objectives, keywords., and exclusion

☐ Description

A topic:

Innovation impact on firm performance

Click here to comment

The topic question:

How do the various factors of Innovation (e.g. knowledge stocks, ideas, innovation processes, R&D investment, employee engagement) link to revenue growth

Main objective

To discover how changes in the input factors (factors of Innovation) flow through to output factors (increased revenues, and maybe other factors such as knowledge stock growth etc). Isolating contextual factors (e.g. industry type, IP regime)

Click here to comment

Secondary objectives

To capture for future reference any collateral data on Innovation metrics in general, for use in later projects.

Insert another row

Click here to comment

Keywords
innovation value
factors of innovation
performance impact of innovation
returns to R&D

Insert a row
Click here to comment

What may be excluded from that topic
Measuring innovation at a level of analysis other than the firm, or a discrete organization within the firm that has responsibility for Innovation management.

Insert a row
Click here to comment

Recommended Materials	Why ?
Oslo manual - 3rd edition (2005) OECD publication	it investigates the field of non-technological innovation and the linkages between different innovation types
The Oxford handbook of Innovation	it looks into how and why Innovation differs across Sectors
Managing Innovation 3rd edition - Tidd and Bessant	a good overview of managing innovation

Insert item
Click here to comment

Insert another topic

Identify what may be excluded from the process in general.

Topic	Comments
Innovation at a level of analysis other than that of the firm, (or a standalone commercial entity within a firm that has IM responsibility). This would diminish the value of studies at the national or regional level.	

Insert a row
Click here to comment

Identify potential resources

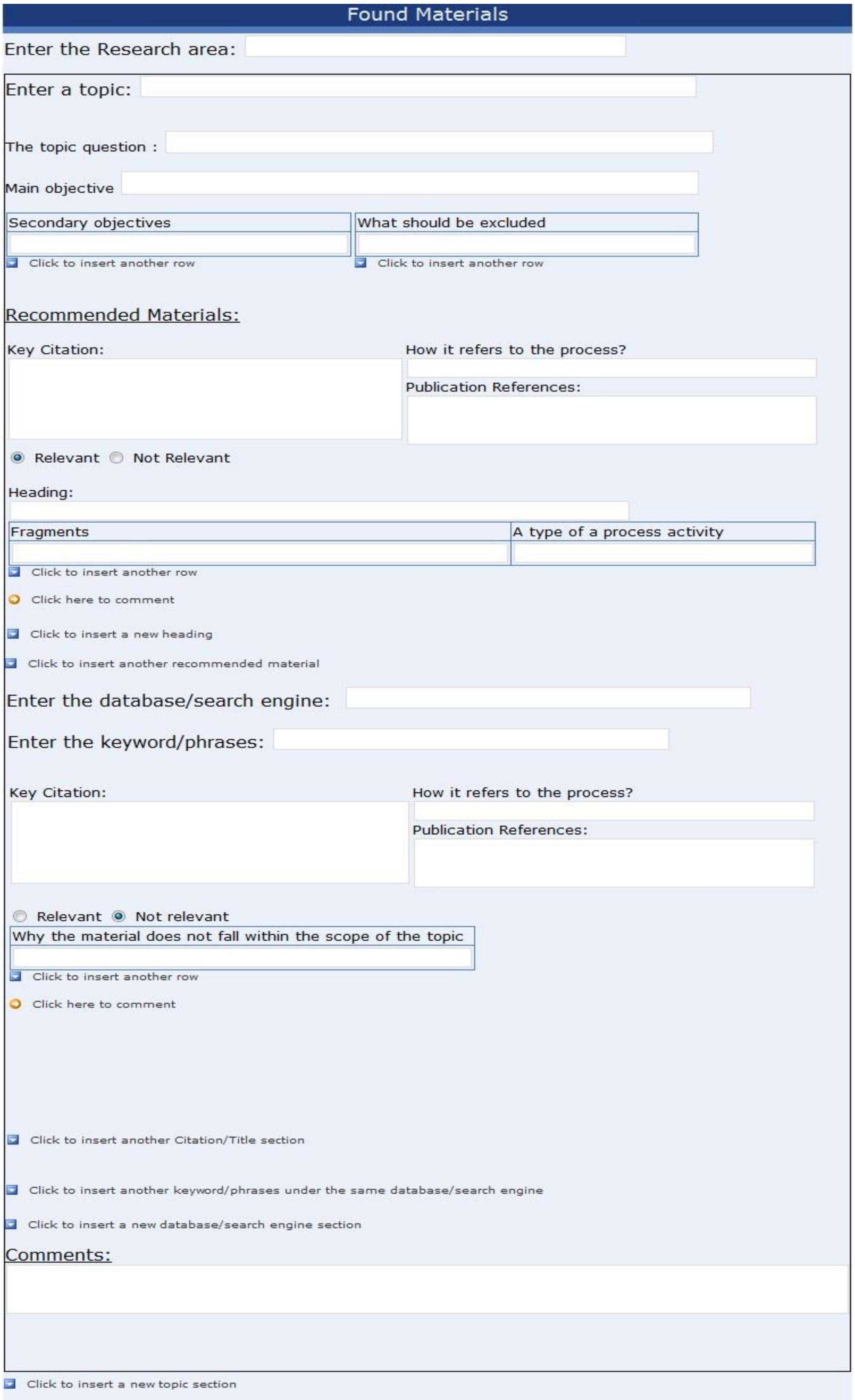
Manual:	**Search engines:**	**Experts**
MIS quarterly executive	Springerlinks	Kline and Rosenberg
European journal of information systems	Ebscohost	David Teece
IEEE transactions on information theory	ACM digital library	Bronwyn Hall
Insert item	Insert item	Sward, David
		Insert item

For a Researcher to include a mind map picture:

Click here to insert a picture

Appendices

Appendix 3



Found Materials

Enter the Research area:

Enter a topic:

The topic question :

Main objective

Secondary objectives	What should be excluded

Click to insert another row
Click to insert another row

Recommended Materials:

Key Citation:

How it refers to the process?

Publication References:

Relevant   Not Relevant

Heading:

Fragments	A type of a process activity

Click to insert another row

Click here to comment

Click to insert a new heading

Click to insert another recommended material

Enter the database/search engine:

Enter the keyword/phrases:

Key Citation:

How it refers to the process?

Publication References:

Relevant   Not relevant

Why the material does not fall within the scope of the topic

Click to insert another row

Click here to comment

Click to insert another Citation/Title section

Click to insert another keyword/phrases under the same database/search engine

Click to insert a new database/search engine section

Comments:

Click to insert a new topic section

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Appendix 4

Scope of Collaboration

Topic Analysis	
What is the goal of collaboration	Click here to enter text.
Which facets of the process will be produced	Click here to enter text.
What will happen with the result	Click here to enter text.
What type of experience is required	Click here to enter text.
What is there for the participants	Click here to enter text.
Group size	Click here to enter text.

Expectations from Participants	
Years of experience	Click here to enter text.
Work background	Click here to enter text.
The area of expertise for the process	Click here to enter text.
What will they contribute	Click here to enter text.
Which level of expertise (strategic, tactical, operational) and why	Click here to enter text.
Roles in organization	Click here to enter text.

Resource Analysis	
The available time	from Click here to enter a date. to Click here to enter a date.
Location	Click here to enter text.
What technology will be used	Click here to enter text.
How participants will be informed	Click here to enter text.
Available budget	Click here to enter text.

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Appendix 5

Agenda for the Focus Group Collaboration

	Activity	Description	Outcome	Method	Tool	Time
Individual Interviews	Understanding practitioner's expertise	The Researcher asks questions about the practitioner's organization, roles and link to the process.	Overview of the organization and the practitioner's key responsibility and areas of interest.	Laddering interview	Grouputer	From 20 to 40 mins
	Gathering activities for the process	The Researcher asks the practitioner questions that are related to their expertise regarding the investigated process.	Identify activities of the domain process, the data input and output, the activity before and after, the task of the activity, and performer	Semi-structure interview	Grouputer	From 40 to 60 mins
Focus Group Meeting	Getting to know each other	Practitioners presents their organization and role to others	Practitioner get to know each other	Ice-Breaker	Grouputer	5 mins each
	Presentation of findings from interviews	The Researcher presents findings from 1 to 1 interview. Questions for clarification can be asked in both directions	Participants get familiar with others contribution.	Group Development	Mikogo	30-40 mins
	Grouping matching activities	Practitioners group activities identified at individual interviews	All findings are grouped and named in a way that everyone agrees on	KJ Method	Grouputer	20 mins
	Constructing the process	Each practitioner is asked to sort the grouped activities in the order of their execution, according to their beliefs.	Groups and activities are sorted according to the practitioners' perspective	KJ Method	Grouputer	10 mins
	Consolidation of the Process	The Researcher joins matching order of grouped activities and hold discussion to determine the right order for the rest.	Groups and activities have the common order of execution established.	KJ Method	Grouputer	40 mins
Conclusions	Summary of the Focus Group Collaboration	The Researcher presents the consolidated process, and provides to each practitioner an access to the group's findings.	The Practitioners have a clear understanding which objectives of the collaboration were met and what the final output is and how to access it.	Group Development	Mikogo	20 mins

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Appendix 6

Language / BWW Constructs	PN	EPC	IDEF3	BPMN
Things				
Thing	✓		✓	✓
Property	✓	✓	✓	✓
Class	✓			✓
Kind				✓
States				
State	✓	✓	✓	
Conceivable state space				
State law	✓	✓		
Lawful state space	✓			
Stable state		✓		
Unstable state	✓			
History				
Events				
Event	✓	✓	✓	✓
Conceivable event space				
Lawful event space				
External event		✓		✓
Internal event	✓	✓		✓
Well-defined event	✓	✓		✓
Poorly defined event				✓
Transformation	✓	✓	✓	✓
Lawful transformation	✓	✓		✓
Coupling			✓	✓
Acts on	✓			✓
Systems				
System			✓	✓
System Composition			✓	✓
System environment				✓
System structure			✓	
System decomposition			✓	✓
Level structure		✓	✓	✓
Sub-system				✓
# BWW constructs representation	***13***	***11***	***11***	***19***

Appendices

Appendix 7

Information Quality of Artefacts

the aim of this questionnaire is to evaluate an artefact by stating how good it corresponds to the sections below.
For example, you were asked a question how legit the artefact is. You would assess it by selecting value on the 11-point type scale. The number 10 is labelled as "Extremely good", while 0 as "Not at all", and 5 as "Average".

Concise representation

IT LOOKS HOW WORDS ARE ARRANGED SO THAT EVERYTHING FITS NEATLY INTO THE SPACE AVAILABLE.

1. How concise is the artefact? ○ 0 ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10
Not at all Average Extremely good

A "concise" artefact will provide information short, with no unnecessary words.

3. How compact is the artefact? ○ 0 ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10
Not at all Average Extremely good

A "compact" artefact will have short description for objects, to get more definitions into a small space

Consistency

IT LOOKS IF THE ARTEFACT REFERS TO AND DOES THINGS THE SAME WAY; HAS THE SAME STANDARDS.

3. How consistent meaning has the artefact? ○ 0 ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10
Not at all Average Extremely good

A "consistent meaning" artefact will use the same sense or significance of a word, symbol for the same purpose.

4. How consistent structure has the artefact? ○ 0 ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10
Not at all Average Extremely good

A "consistent structure" artefact will use the same way in which the objects of the artefact are connected with each other and form a whole.

5. How is the artefact presented in the same format? ○ 0 ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10
Not at all Average Extremely good

A "the same format" artefact will arrange objects in the same way.

Ease of understanding

IT LOOKS IF A PERSON IS ABLE TO THINK ABOUT AN OBJECTS DESCRIBED AND USE CONCEPTS TO DEAL ADEQUATELY WITH THAT OBJECT.

6. How easy is the artefact to understand? ○ 0 ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10
Not at all Average Extremely good

A "easy to understand" artefact will stress a person the full awareness or knowledge arrived at the object.

7. How easy is the artefact to comprehend? ○ 0 ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10
Not at all Average Extremely good

A "easy to comprehend" artefact will make a person to grasp knowledge without the full awareness what it meant.

8. How easy is to identify key points of the artefact? ○ 0 ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10
Not at all Average Extremely good

A "easy to identify key points" artefact will make a person spot key points on ease.

nterpretability

T LOOKS HOW THE ARTEFACT PRESENTS OR CONCEPTUALIZES THE MEANING OF BY MEANS OF ART OR CRITICISM.

). How interpretable is the artefact? ○ 0 ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10
Not at all Average Extremely good

A "interpretable" artefact will be understandable without explanation.

10. How is the artefact without inappropriate language and symbols? ○ 0 ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10
Not at all Average Extremely good

A "without inappropriate language and symbols" artefact will only use language and symbols relevant to presented objects.

11. How readable is the artefact? ○ 0 ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10
Not at all Average Extremely good

A "readable" artefact will be clear and easy to read.

Appendices

Appendix 8

The blueprint of the reference model is available at http://theprocessorientedreferencemodel.tk. Figure 7.1 illustrates a screenshot from the website. The blueprint serves as a guideline for design science researchers investigating and constructing business process model artefacts. It is the base for future instantiations of the reference.

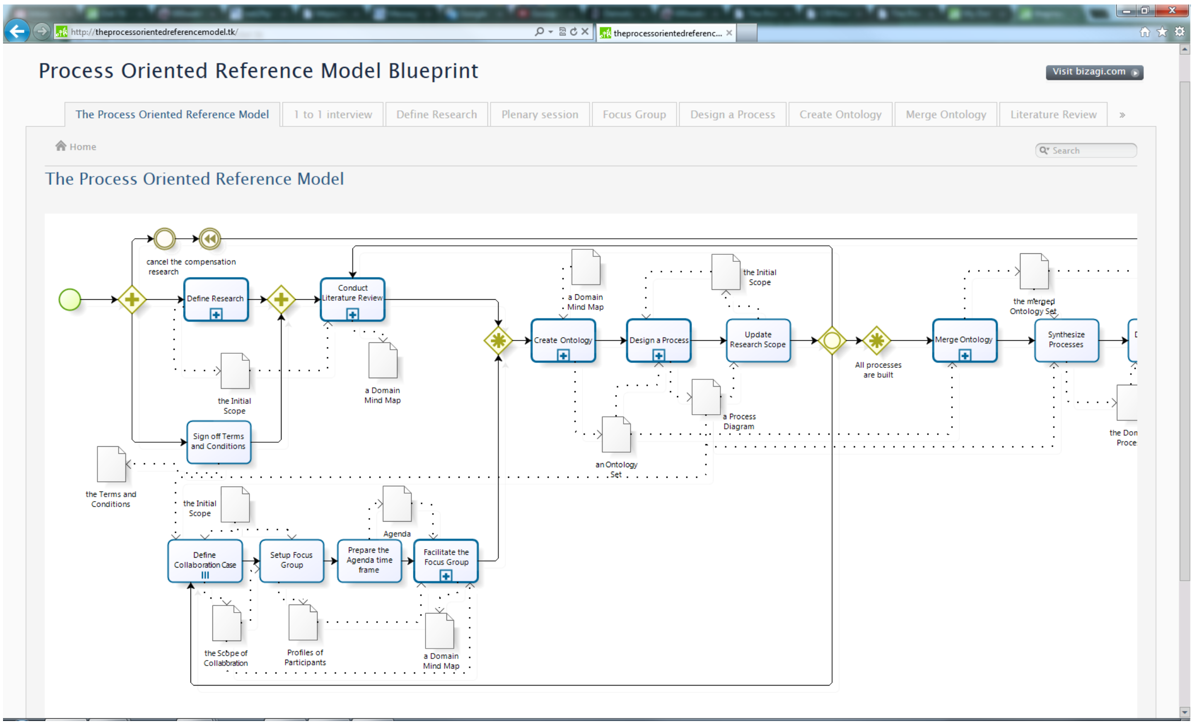

Figure 7.1 Screenshot of the reference model website

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