Design Science Research Constructs: a Conceptual Model

Completed Research Paper

Stefan Cronholm **Hannes Göbel**

Abstract

Design science research (DSR) has become an accepted as well as legitimated research paradigm within the IS discipline. DSR has had a significant impact on IS research and it has the potential to become even more successful. One reason for not being fully adopted is due to gaps in the understanding of DSR constructs. Our literature review has revealed that constructs often are: abstract, synonymous, overlapping, offering slightly different definitions, and difficult to grasp. One implication of these problems is that it might be hard to communicate research results not only to other researchers within the DSR community but also to other disciplines. Consequently, the purpose of this study has been to suggest a conceptual model that includes key DSR constructs and their relationships that can contribute to the understanding and communication of the DSR phenomenon.

Keywords: Design Science Research, Design Research, Design Science, Design Theory, Design Principles.

Introduction

The field of Design Science Research (DSR) has become an accepted as well as legitimated research paradigm within the IS discipline (Gregor and Hevner 2013). Venable and Baskerville (2012 p.141) define DSR as "Research that invents a new purposeful artefact to address a generalized type of problem and evaluates its utility for solving problems of that type". Hevner and Chatterjee (2010, p.5) define DSR as follows: "Design science research is a research paradigm in which a designer answers questions relevant to human problems via the creation of innovative artifacts, thereby contributing new knowledge to the body of scientific evidence. The designed artifacts are both useful and fundamental in understanding that problem". Kuechler and Vaishnavi (2008, p.6) add that the purpose of DSR is to address "… important unsolved problems in unique or innovative ways or in the development of more effective and efficient solutions to previously solved problems".

Although DSR has had a significant impact on IS research, it has not yet reached its potential in the IS community. Gregor and Hevner (2013, p.337) state that "… DSR has yet to attain its full potential impact on the development and use of information systems due to gaps in the understanding and application of DSR concepts and methods" and further that "…ongoing confusion and misunderstandings of DSR's central ideas and goals are hindering DSR from having a more striking influence on the IS field" (p.338). Besides these statements, our literature review has revealed that there exist several DSR constructs that are: abstract, synonymous, overlapping, offering slightly different definitions, and difficult to grasp. Schön (1983) state that constructs provide a language in which problems and solutions are defined and communicated. Hevner et al. (2004) add that a construct consists vocabulary and symbols. Moreover, they are included in a broader conceptual structure, which implies that there probably exist relationships between the constructs. In the DSR literature, these relationships are sometimes implicit or not discussed at all. One implication of this vagueness is that it might be hard to communicate design science research not only to researchers within the DSR community but also to other disciplines. Consequently, we can conclude that there is a need for enhanced conceptual clarity in DSR. Conceptual clarity is emphasised in Goldkuhl (2018) who claims that both the semantic and relational dimension of constructs are essential aspects of communication.

One way to reduce conceptual confusion is to create conceptual models. Wand and Weber (2002, p.363) state that "…conceptual modeling involves building a representation of selected phenomena in some domain". According to Wand and Weber (2002), conceptual models include a set of constructs and rules that are combined to model real-world domains or phenomena. Goldkuhl (2004, p.66) states that "… a conceptual analysis should include an analysis of the existing and possible definitions of categories" and raises the following important issues: "Are the categories clear and understandable?" and "Are they proper delimitations of phenomena in the world?". Some purposes of conceptual models are: supporting communication, helping analysts understand a domain, and providing input for the design process (ibid.). These purposes correspond well to the purpose of this study, which is to suggest a conceptual model that includes DSR key constructs and their relationships. We hope that our suggested model will support especially novice followers of DSR to gain an improved understanding of DSR.

Our literature review concerning existing conceptual models identified a few models describing DSR constructs and relationships between key constructs. All these models provided valuable input to the purpose of our study. However, they all presenting DSR concepts from one aspect and are thus lacking some important DSR constructs. Consequently, our research process was cumulative since our suggested model was built on these models and extended by theoretical insights concerning DSR constructs from a comprehensive literature review. The following section presents an analysis of existing conceptual models. Thereafter, we describe the research method. Next, the identified DSR constructs are introduced, and then we illustrate the conceptual model. After that, we compare our conceptual model to the existing models. Finally, conclusions are drawn.

The State of the Art Concerning Existing Models

Our literature review has identified a number of conceptual models describing DSR constructs and relationships between constructs. Due to limited space, we could only present a summary of the models.

We encourage the interested reader to gain complementary information about each model from their original publication. The purpose of this section is to present existing models and to argue for the need for an elaborated conceptual model.

One conceptual model is presented by Walls et al. (1992, 2004) and is called 'Relationships Among ISDT Components' (see Figure 1). (ISDT is short for Information Systems Design Theory, and we interpret 'component' as synonymous to 'construct'). The purpose of the model is to depict components and relationships between components of ISDT. The model is based on a review of existing ISDT and on the claim that 'design' refers to both a product and a process. The model includes six components (kernel theory, meta-requirements, meta-design, design method, testable design product hypotheses and testable design process hypotheses. Walls et al. (2004) state that the model shows how kernel theories (external theories that inform artefact construction) govern the design process. The component meta-requirements corresponds to a class of goals. The term 'meta-requirement', rather than 'requirement', is used since a design theory does not address a single problem but a class of problems. The meta-design refers to a class of artefacts and not to a specific artefact (instantiation). The design method describes procedures for artefact construction. The component of testable design hypotheses is aiming at verifying whether or not the artefact meets the meta-design and the meta-requirements.

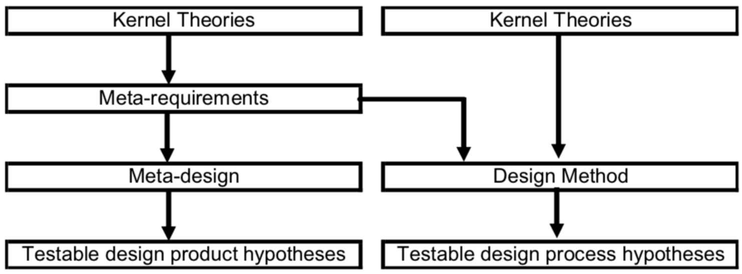

Figure 1. Relationships among ISDT components (Walls et al. 2004)

Another identified model suggested by Kuechler and Vaishnavi (2008) is based on a general model concerning logical relationships between explanatory and prescriptive statements (Goldkuhl 2004) (see Figure 2). Goldkuhl (2004) suggest that 'the cause' and 'the effect' in the explanatory statement correspond respectively to 'the prescribed action' and 'the goal' in the prescriptive statement. Kuechler and Vaishnavi (2008) have added the components highlighted in grey and the dotted lines (see Figure 2). Out interpretation is that Kuechler and Vaishnavi (2008) positioned the general model suggested by Goldkuhl (2004) in a DSR context and consequently added DSR components such as kernel theories, mid-range theories and design theories. Kuechler and Vaishnavi (2008, p.490) describe kernel theories as explanatory theories that "… originate outside the IS discipline and suggest novel techniques or approaches to IS design problems". Mid-range theories are also explanatory but of limited scope. Mid-ranges theories also constitute a conceptual bridge between kernel theories and design theories (ibid.) Finally, Kuechler and Vaishnavi (2008, p.490) state that "Design theories give explicit prescriptions for 'how to do something". Kuechler and Vaishnavi (2008) associate the explanatory statement with kernel theories and the prescriptive statement with design theories. Moreover, Kuechler and Vaishnavi (2008) included the components 'artifact evaluation' and 'evidence', which add an iterative aspect to the model.

A third identified model is presented by Hevner et al. (2004) (see Figure 3). The authors refer to this model as a conceptual framework, and the purpose of the framework is to support "… understanding, executing, and evaluating IS research combining behavioral-science and design-science paradigms" (p.79). The framework consists of three major parts: Environment, IS Research and Knowledge Base. The Environment includes the phenomenon of interest and defines the problem space. The IS Research is divided into two sub-parts: Develop/Build and Justify/Evaluate. From a DSR perspective, the purpose of Build and Evaluate is to construct artefacts that meet the identified business need. From a behavioural science perspective, the purpose of Develop and Justify is to create theories that explain or predict phenomena related to the identified business need (ibid.).

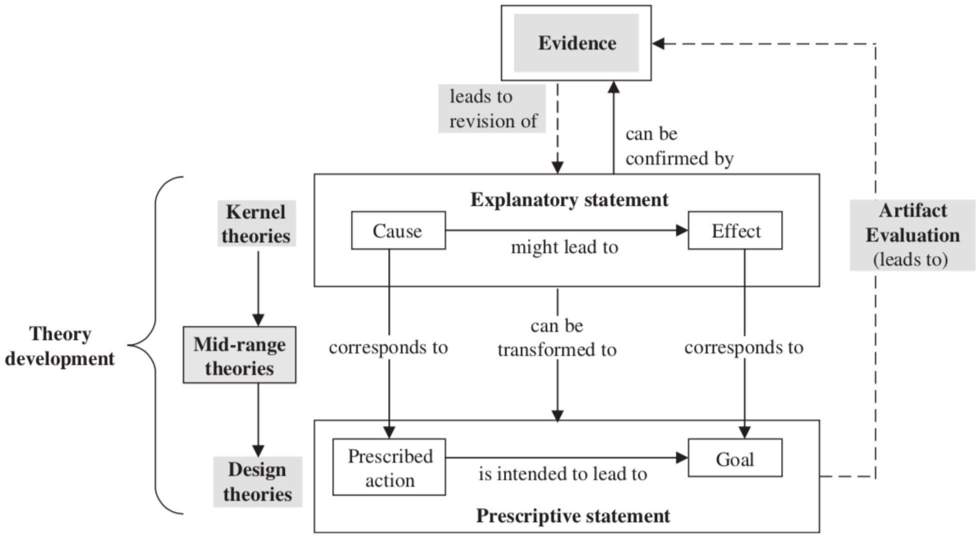

Figure 2. Relationships among kernel theory, mid-range theory and design theory, and the design process (Kuechler and Vaishnavi 2008 (modified from Goldkuhl 2004))

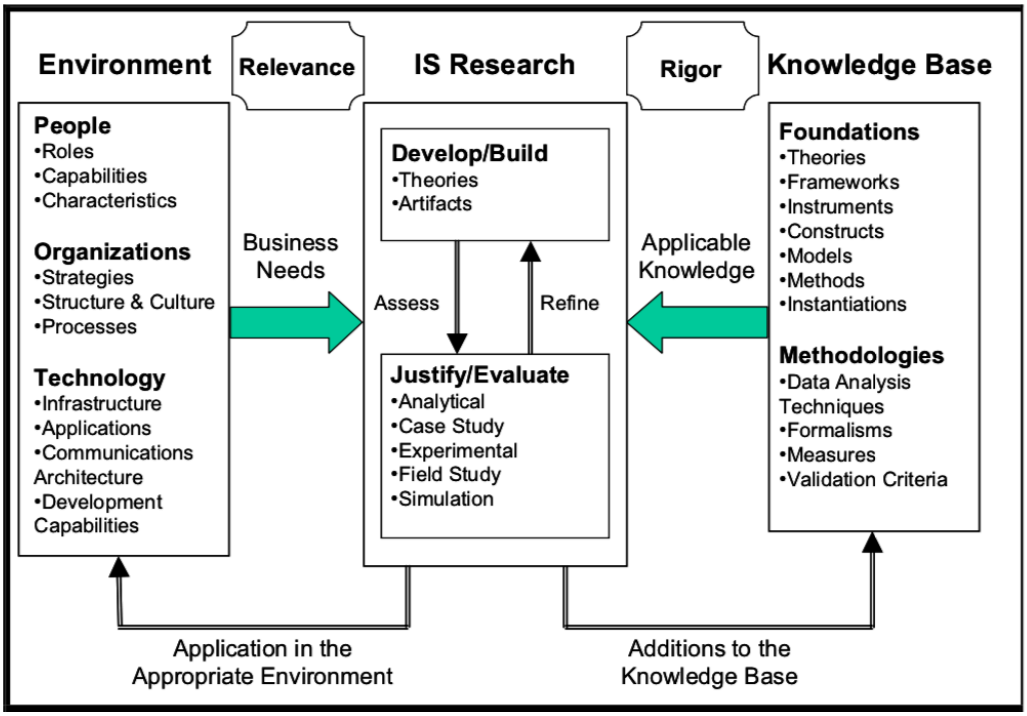

Figure 3. Information Systems Research Framework (Hevner et al. 2004)

We can conclude that the existing models include important DSR constructs and relationships. However, they are presented from a specific aspect and therefore they lack some essential constructs. Examples are class of problems, design principles and artefact mutability. This observation is not a criticism of existing models, and we are fully aware that the purpose of the models has not been to present a conclusive picture of DSR constructs. However, the models represent state of the art concerning existing models that include DSR constructs and consequently they are essential to recognise when suggesting an extended conceptual model.

Research Method

In order to identify and analyse the key constructs of DSR, we have followed the literature review method suggested by Webster and Watson (2002). This literature method consists of the following activities: 1) identifying the relevant literature, 2) structuring the review, and 3) theoretical development**.**

1) Identifying the relevant literature: According to Webster and Watson (2002), the significant contributions are likely to be in the leading journals, and an excellent way to select articles is to review the citations for the articles identified to determine which articles to consider. Consequently, we have reviewed the eight top IS journals according to the AIS Senior Scholar's Basket of Journals: European Journal of Information Systems (EJIS), Information Systems Journal (ISJ), Information Systems Research (ISR), Journal of Association of Information Systems (JAIS), Journal of Information Technology (JIT), Journal of Management Information Systems (JMIS), Journal of Strategic Information Systems (JSIS) and, Management Information Systems Quarterly (MISQ). We have also reviewed the publications in all the conferences on design science research in information systems and technology (DESRIST) and other relevant literature by following citations in these journals and conference papers. We have found that many scholars have contributed to design science research in the selected literature. In this study, we have not reviewed articles that are applying DSR without reflecting on DSR. These articles are typically developing design principles of some kind and are not elaborating on DSR constructs. The key constructs of DSR were identified by analysing: central DSR topics discussed, frequently used DSR constructs, and specified keywords. We use the keywords design science, design research and design science research to search for relevant articles.

2) Structuring the review: Webster and Watson (2002) state that "A review succeeds when it helps other scholars to make sense of the accumulated knowledge of a topic." (p.xviii). Moreover, they claim that "A literature review is concept-centric" (p.xvi), which means that concepts (e.g. constructs) determine the organising framework of the review. In order to bring order among the key DSR constructs identified in the literature, we have used the concept-centric matrix suggested by Webster and Watson (2002). The structure of the review also included the grouping of similar key constructs (see Table 1).

3) Theoretical development: Webster and Watson (2002, p.xix)) state that "A review should identify critical knowledge gaps and thus motivate researchers to close this breach". This means to highlight the discrepancy between what we know and what we need to know. The purpose of this activity was to extend existing theories by: a) identifying, describing and explaining key constructs, and 2) identifying and presenting relationships between key constructs. The relationships were identified by analysing statements identified in the literature. One example of such a statement is identified in (Sein et al. 2011). The statement reads "Cast the problem as an instance of a class of problems" (Sein et al. 2011). This statement includes two key constructs 'problem' and 'class of problems'. The statement also indicates that there is a relationship between the two constructs. In sections 'Introduction' and 'The State of Art Concerning Existing Models', we have described what we know and what we need to know regarding the topic of our study. In the sections 'Key Constructs of DSR' and "A DSR Conceptual Model', we have identified key constructs and developed a conceptual model that represents knowledge corresponding to what we need to know. In order to clarify how our conceptual model advances existing knowledge, we compared our model with the existing models concerning similarities and differences concerning constructs and relationships.

4) Evaluation of the model: The conceptual model is evaluated by the use of an artificial strategy (Venable et al. 2016). This means that we have evaluated the model in an artificial setting and used theoretical arguments. The evaluation process consisted of two steps. First, the authors of this paper evaluated the model individually by comparing the models' key constructs and relationships to theoretical statements and claims. Then, the two authors reconciled their individual findings further enhance the model. The evaluation process including the two steps was carried out in three iterations.

Key Constructs of DSR

In this section, we present the identified key constructs of DSR (see Table 1). The purpose of Table 1 is to present the concept-centric matrix that forms an overview of DSR constructs and informs about which articles we have consulted. The following sub-sections include a deepened discussion of each key construct individually. In order to make DSR easier to grasp, we also present constructs that are either synonymous or similar to each other.

Table 1. Identified DSR key constructs

Key construct/ Publication	Design theory	Kernel theory	Meta-Requirement (Class of goals)	Context	Class of Problems	Meta-Design (Class of artefact)	Artefact	Design principles	Building and Evaluation	Theorising and Justificatio	Artefact Mutability
Chandra et al. (2015)	X	X	X	X		X	X	X	X		
Cronholm and Göbel (2018)	X		X	X	X		X	X	X	X	
Goldkuhl (2004)	X	X		X			X		X	X	
Gregor and Hevner (2013)	X	X	X	X	X	X	X	X	X	X	
Gregor and Jones (2007)	X	X	X	X		X	X	X	X	X	X
Hanseth and Lyytinen (2010)	X	X		X	X		X	X	X	X	
Hevner (2004)	X	X		X	X	X	X	X	X	X	
Hevner and Chatterjee (2010)	X	X	X	X	X	X	X	X	X	X	X
Iivari (2007)	X	X	X	X		X	X		X	X	
Kuechler and Vaishnavi (2008)	X	X					X	X	X	X	X
Markus et al. (2002)	X	X		X	X		X	X	X	X	
Purao (2002)	X	X	X	X			X	X		X	
Sein et al. (2011)		X	X	X	X	X	X	X	X	X	X
Simon (1996)	X	X		X			X		X	X	X
Vaishnavi et al. (2004)	X	X		X			X	X	X	X	
Van Aken (2004)	X			X	X		X	X	X	X	
Van den Akker (1999)	X			X				X		X	
Venable (2006)	X	X	X	X	X	X	X	X	X	X	
Venable et al. (2016)	X			X			X	X	X	X	
Walls et al. (1992)	X	X	X	X	X	X	X	X	X	X	
Walls et al. (2004)	X	X	X	X	X	X	X	X	X	X	
Winter (2008)	X	X		X	X		X		X	X	

Design Theory

Gregor (2006) identifies five types of theory in IS (Analysing, Explaining, Predicting, Explaining and Predicting, Design and Action) and claim that a design theory belongs to the type of 'Theory for Design and Action'. The essence of this type is to say *how to do something* (ibid, p.620). Gregor and Hevner (2013) claim that the overall goal of design theory is to formalise design knowledge. Another claim is that design theory should be based on kernel theory and guide practitioners (Walls et al. 1992; Markus et al. 2002, p.181). Goldkuhl (2004, p.60) define design theory "to be a prescriptive theory which integrate[s] normative and descriptive theories into design paths intended to produce more effective information systems" and Walls et al. (1992) claim that a design theory explains how an artefact should be constructed. Gregor and Hevner (2013, p.339) add that design theory "… gives prescriptions for design and action". Moreover, "Design theories are theories of procedural rationality" (Walls et al. 1992, p. 41; Simon, 1996). According to Markus et al. (2002, p.181), design theory includes a package of three interrelated elements "a set of user requirements, a set of system features (or principles for selecting system features), and a set of principles deemed effective for guiding the process of development". Hanseth and Lyytinen (2010) express this package in a similar way: "(1) a set of design goals shared by a family of design problems; (2) a set of system features that meet those goals; and (3) a set of design principles and rules to guide the design so that a set of system features is selected to meet chosen design goals". Moreover, Hanseth and Lyytinen (2010, p.5) emphasise that "Each design theory applies *in a certain design context* in which *a specific set of system goals* have been selected, and *apply to a specific class of systems* and *associated design processes*". Finally, Walls et al. (1992) state "The objective of a design theory is to prescribe both the properties of an artefact … and the method(s) of artifact construction". Based on these definitions and statements, we can conclude that design theory can play two roles: 1) something that is created as a result from a DSR project, and 2) something that is applied in an IS development project or DSR project in order to guide the development of artefacts.

Kernel Theory

Kuechler and Vaishnavi (2008, p.4) define kernel theory as "… fundamental research in the natural and social sciences" and Gregor and Hevner (2013, p.340) claim that "Kernel theory refers to any descriptive theory that informs artifact construction". Walls et al. (1992, p.41) state that "Design theories are composite theories which encompass kernel theories from natural science, social science and mathematics" and Iivari (2007) regards kernel theory as a necessary component of design theory and states that "… without a sound kernel theory it is not justified to speak about 'design theory'." (Iivari 2007, p.49). The purpose of kernel theory has been expressed in slightly different ways by several scholars, such as: "Kernel theories advise design solutions; possibility of refinement or development" (Simon 1996), "Theories from natural and social sciences governing the design". (Walls et al. 2004, p.46) and "A mature body of design knowledge should include kernel theory because such theory explains, at least in part, why the design works." (Gregor and Hevner, 2013, p.340). We have also identified the construct of justificatory knowledge (Gregor 2006; Gregor and Jones 2007; Gregor and Hevner, 2013), which we interpret as similar to kernel theory. Gregor and Hevner (2013, p.340) state that "We employ the term justificatory knowledge to be nearly synonomous [sic!] with kernel theory." (Gregor and Hevner, 2013, p.340). Gregor and Jones (2007, p.328) describe justificatory knowledge as follows: "The justificatory knowledge provides an explanation of why an artifact is constructed as it is and why it works, and explanations are usually regarded as a desirable part of a theory specification, assisting with their communicative purpose and the facilitation of human understanding" (Gregor and Jones 2007, p.328). The difference between kernel theory and justificatory knowledge is explained by Gregor and Hevner (2013, p.340) and reads "Justificatory knowledge has a slightly broader meaning and here it is taken to include any knowledge that informs design research, including informal knowledge from the field and the experience of practitioners". One conclusion from analysing the construct of kernel theory is that kernel theories guide the development of and are integrated with design theories. There seems to be an agreement in the examined literature that there is a need for complementing knowledge or kernel theories when designing artefacts.

Meta-Requirement

A meta-requirement "Describes the class of goals to which the theory applies" (Walls et al. 1992, p.43; Walls et al. 2004, p.46). Gregor and Jones (2007) suggest the term 'purpose' which is defined as "the set of meta-requirements or goals that specifies the type of system to which the theory applies". Gregor and Jones (2007, p.325) clarify the meta-aspect of the term 'meta-requirement' by stating that "These theory requirements are meta-requirements; they are not the requirements for one instance of a system, as would be the case if there was a need to build a single system in industry". Purao (2002, p. 22) also discusses the construct of meta-requirement and claim it addresses the realm of theory. Walls et al. (1992) emphasise the importance of goals and claim that "Design theories must deal with goals as contingencies" (Walls et al. 1992, p.40) and that "Goal orientation is the key element required in a design theory" (Walls et al. 1992, p.40). We can conclude that the constructs of meta-requirement and class of goals are used similarly by several scholars. We can also conclude that the prefix 'meta' is used to emphasise the theoretical aspect of a DSR project.

Context

According to Hanseth and Lyytinen (2010, p.5), "The design context is determined by the nature of the system, its size, the design phase, the type of technology, the type of users or designers". Sein et al. (2011, p.37) discuss the term organisational context and state that "IT artifacts are ensembles shaped by the organizational context during development and use". Venable et al. (2016, p.78) discuss the construct of context in the light of evaluation and state that "In a design science project, evaluation must also regard the design and the artefact in the context of the knowledge it contributes to the knowledge base". We have found a number of similar constructs that are appropriate to describe in relation to the construct of context. Gregor and Jones (2007, p.322) use the construct of scope and claim that the meta-requirements define the scope, or boundaries, of the theory. The construct of scope is also used by Goldkuhl (2004, p.60) who claims that "The scope of such a theory [design theory] is both the design product and the design process." Furthermore, Chandra et al. (2015) stress the importance of the construct of context to develop design principles that are more precise. They claim that "The precision can be achieved by outlining boundary conditions, within which the design principle applies. The boundary conditions can be explained through a statement of relevant use context or intended user group." (Chandra et al. 2015, p.4045). We can conclude that the construct of context is discussed from two perspectives: a) from a design perspective where the organisational characteristics define the design context, and b) from a theoretical perspective where the context supports the generation of a class of problems, the meta-requirements, and the meta-design.

Class of Problems

Hevner et al. (2004, p.85) state that "… a problem can be defined as the differences between a goal state and the current state of a system". In DSR, it is not sufficient to address an instance of a problem. Rather, DSR is about "… constructing an artifact that "works" well for the specified class of problems" (Hevner et al. 2004. p.89). Hanseth and Lyytinen (2010) are also discussing the construct of a class of problems, and they state that design theory "… has denoted a set of constructs … which help designers map a class of design problems to effective solutions that meet design goals" (p.5). This view is shared by Sein et al. (2011, p.39) who state that the researchers "… seeks to develop prescriptive design knowledge through building and evaluating innovative IT artifacts intended to solve an identified class of problems". In the Action Design Research method, there is an explicit recommendation that reads "Cast the problem as an instance of a class of problems" (Sein et al. p.41). Consequently the researcher "… should generate knowledge that can be applied to the class of problems that the specific problem exemplifies" (Sein et al. 2011, p.40). Markus et al. (2002) state the class of problems should be solved by a set of general design principles. Our analysis has revealed that DSR is not only about identifying knowledge based on problems occurring in single business contexts. Rather, the research should generate general knowledge regarding a class of problems. This general knowledge can be included in a design theory, which then can be used in other contexts facing similar problems.

Meta-Design

The meta-design represents the class of artefacts. Walls et al. (1992) and Iivari (2007) explicitly state that it describes the class of artefacts hypothesised to meet the meta-requirements (the class of goals). Gregor and Jones (2007, p.319) add that the meta-design is tested by design product hypotheses to understand whether it satisfies the meta-requirements. Kuechler and Vaishnavi (2008, p.496) state that "the goals of the development derive from the meta-requirements for the artifact" and similarly to Gregor and Jones (2007) they state that the "evaluation measurements then test the hypotheses that our meta-design has realized those goals". Sein et al. (2011) discuss meta-design in relation to their principle of 'Guided Emergence' which has the purpose of combining "the interplay between the two seemingly conflicting perspectives [design and emergence]" (p.44). They claim that the guided emergence of the

IT artefact includes not only trivial fixes but also substantial changes to the design and the meta-design. It is evident that several scholars emphasise the need for meta-design. Similar to the construct of meta-requirement, meta-design should embrace the knowledge that is useful outside the specific context. Consequently, the knowledge regarding the particular context is reconceptualised into a class of solutions (the meta-design).

Artefact

Hevner and Chatterjee (2010, p.5) define an artefact as follows: "The term *artifact* is used to describe something that is artificial, or constructed by humans, as opposed to something that occurs naturally". Gregor and Jones (2007, p.322) suggest a short and concise definition: "a physical implementation of the artifact theory" while Hevner et al. (2004, p.78) state that "Purposeful artifacts are built to address heretofore unsolved problems". With respect to the construct of artefact, Purao (2002, p.5) compares DSR to other research disciplines and concludes, "... the most *visible* output of the design research tradition is the artifacts, unlike the conventional research traditions, whose visible output is theories, facts, laws and assertions". A common understanding is that artefacts can consist of constructs, models, methods and instantiations (e.g. March and Smith 1995; Hevner et al. 2004; Hevner and Chatterjee 2010**). '**Constructs' is defined as follows: "conceptualization used to describe problems within the domain and to specify their solutions" (March and Smith 1995, p.256), "vocabulary and symbols" (Hevner et al. 2004, p.77), "concepts with which to ... characterize phenomenon" (Walls et al. 2004, p.48), and "representations of the entities of interest in the theory" (Gregor and Jones 2007, p.322). There are also several definitions of 'model': "… a set of propositions or statements expressing relationships among constructs" (March and Smith 1995, p.256), "describe tasks, situations, or artifacts" (Walls et al. 2004, p.48) and "abstractions and representations" (Hevner et al. 2004, p.77). 'Method' is defined as follows: "… a set of steps (an algorithm or guideline) used to perform a task." (March and Smith, 1995 p.256), "ways of performing goal directed activities" (Walls et al. 2004, p.48) and "algorithms and practices" (Hevner et al. 2004, p.77). Finally, definitions of 'instantiation' read: "An instantiation is the realization of an artifact in its environment" (March and Smith, 1995, p.258), "physical implementations intended to perform certain tasks" (Walls et al. 2004, p.48) and "instantiations are problem specific by definition, instantiation design is always solution engineering; it may include adaptation of situational (reference) models, situational methods, and situational constructs" (Winter 2008, p.471). Our literature review has revealed that several researchers' definitions of the construct of artefact in the field of DSR are broad and socio-technical. Based on these definitions, we can also conclude that the creation of an artefact is one of the most prominent constructs in DSR and that the artefact serves as a point of departure for reflection and theory generation.

Design Principles

Design principles represent design knowledge and constitute a prescriptive component that is included in the design theory (Cronholm and Göbel, 2018). Similarly, Van Aken (2004) state that prescriptions, such as design principles, is an important category of design knowledge. Gregor and Jones (2007) argue that a design theory should include principles of form and function. This is described as "the abstract "blueprint" or architecture that describes an IS artifact, either product or method/intervention" (ibid, p.322). Chandra et al. (2015, p.4039) regard design principles as "an important vehicle to convey design knowledge that contributes beyond instantiations applicable in a limited context of use". Sein et al. (2011, p.45) add, "The design principles capture the knowledge gained about the process of building solutions for a given domain, and encompass knowledge about creating other instances that belong to this class". Markus et al. (2002) claim that there are two types of design principles which are inextricably intertwined (principles governing the development or selection of system features and principles guiding the development process). Consequently, design principles are of both substantive and procedural nature. Van den Akker (1999) state that the substantial nature guides the characteristics of the artefact and the procedural nature guides how something should be developed.

Another characteristic of design principles concerns the abstraction level. Chandra et al. (2015, p.4045) stress that "… it is important that a design principle is formulated sufficiently abstract to leave some space for different instantiations in different contexts that share the defined boundary conditions".

Cronholm and Göbel (2018) also recognise the importance of abstraction but add that they design principles need to be formulated on both high-levels and low-levels of abstraction to support understanding and reusability. Consequently, design principles concern both the development of products and processes, and their purpose is to guide the design of the artefact. In our literature review, we have found a few suggestions for how design principles can be formulated. We have omitted these formulations since they are out of the scope of this study.

Building and Evaluation

Walls et al. (2004, p.46) emphasise the need for "… a design method that describes procedures for artifact construction". Hevner et al. (2004, p.78) state "The design process is a sequence of expert activities that produces an innovative product". Undoubtedly, DSR includes a process that prescribes what to do and how to do something. March and Smith (1995) explicitly identify the processes of build and evaluate. Building is defined as "the process of constructing an artifact for a specific purpose" and evaluation is defined as "the process of determining how well the artifact performs" (March and Smith 1995, p.254). Goldkuhl et al. (2004, p.65) express the need for goal orientated design process and state "An action prescription includes an explicit (or at least implicit) reference to a goal to be attained" (Goldkuhl 2004, p.65). Sein et al. (2011, p.77) describe evaluation as a process to "evaluate IT artifacts intended to solve identified organizational problems". Venable et al. (2016, p. 77) add that "Evaluation of design artefacts and design theories is a key activity in Design Science Research (DSR), as it provides feedback for further development and (if done correctly) assures the rigour of the research". Moreover, Venables et al. (2016) emphasise the importance of evaluation strategies and discusses a number of evaluation properties such: utility, novelty, quality, completeness, ease of use, effectiveness, and efficacy. Similarly, Vaishnavi et al. (2004, p.1) state the evaluation is an important activity that includes "the analysis of the artifact's use and/or performance with reflection and abstraction". Moreover, Sein et al. (2011, p77) emphasise that "…prescriptive theories must be evaluated with respect to the utility provided for the class of problems addressed." This emphasis is in line with Walls et al. (2004) who claim that the purpose of an evaluation is "… to test whether the meta-design satisfies the meta-requirements" (Walls et al. 2004, p.43). Venable et al. (2006, p.77) have also observed the importance of evaluating both the class and the instance of the class. They state "Evaluation is primarily concerned with evaluation of design science outputs, including Information Systems (IS) Design Theories (Gregor & Jones, 2007) and design artefacts (March & Smith, 1995)". Our analysis has revealed that the two constructs of building and evaluation closely interwoven and that they address both the instance of the artefact as well as the class of the artefact.

Theorising and Justification

In the DSR literature, there are two interlinked constructs: theorising and justification. Theorising concerns the process of *generating* theory (Marsh and Smith 1995) while justification is about *validating* the theory (Goldkuhl 2004). March and Smith (1995, p.259) claim "... it is important to determine why and how the artifact worked or did not work within its environment". March and Smith (1995) restrict the theorising to include natural science methods. Following Venable (2006), we presume that social and behavioural methods can be included in the process of theorising. The need for theorising is clearly explained by March and Smith (1995). They state that "Theories explicate the characteristics of the artifact and its interaction with the environment that result in the observed performance." (p.259). Moreover, Iivari (2007) emphasises that the process of theorisation should be based on a sound kernel theory. Gregor and Jones (2007, p.314) claim that theory in DSR "… encompasses what might be termed elsewhere conjectures, models, frameworks, or bodies of knowledge-terms that are used in connection with design science by many authors".

Justification includes gathering evidence that proves that the theory works. Gregor and Jones (2007, p.322) define justification as follows: "the underlying knowledge that gives a basis and explanation for the design theory". Goldkuhl (2004, p.65) claims that "prescriptive statements should include justification regarding value grounding (usefulness of something), conceptual grounding (analysis of the constructs and their meaning to the specific context) and explanatory grounding (grounding of prescriptive statements in explanations of theoretical nature)". In order to satisfy this claim, three grounding processes are suggested: internal grounding, empirical grounding and theoretical grounding (ibid.). Similarly, Van den Akker (1999, p.9) discusses justification and claims that "…the value of that knowledge will strongly increase when justified by theoretical arguments, well-articulated in providing directions, and convincingly backed-up with empirical evidence". Gregor and Jones (2007) use the term testable propositions that are defined as follows "… hypotheses about the system or tool to be constructed" (p.327). Theoretical propositions can be tested through an instantiation, by building and evaluating an artefact. Walls et al. (2004, p.46) discuss 'testable design product hypotheses' which we interpret as being synonymous with testable propositions. The purpose of 'testable design product hypotheses' is to "… test whether the meta-design hypotheses satisfies [sic!] the meta-requirements" (ibid. p.46). Based on these definitions and descriptions of 'theorising' and 'justification', we can conclude that both these constructs are essential in order to formulate a design theory that is grounded in kernel theories and empirical evidence.

Artefact Mutability

Artefact mutability concerns the changes of the artefact in accordance with theoretical foundations. Gregor and Jones (2007, p.322) define artefact mutability as follows "The changes in state of the artifact anticipated in the theory". Artefact mutability reflects the changes in the theoretical foundations during building and evaluation. Gregor and Jones (2007, p.326) state that "We believe that the lack of theories about IT artifacts, the ways in which they emerge and evolve over time, and how they become interdependent with socio-economic contexts and practices, are key unresolved issues for our field and ones that will become even more problematic in these dynamic and innovative times". Simon (1996) uses a similar construct of 'evolving artefact' that includes flexibility and adaptability that are enabled by feedback from iterative design. Sein et al. (2011) discuss mutability in terms of 'Guided emergence'. The purpose of guided emergence is to "… reflect not only the preliminary design (see Principle 2) created by the researchers but also its ongoing shaping by organizational use, perspectives, and participants" (Sein et al. 2011, p.44). Moreover, Gregor and Iivari (2007) provide a framework for thinking about design theories that provide for the mutability in artefacts. We can conclude that the construct of artefact mutability reflects the dynamic evolvement of the artefact. We can also conclude that there is an interplay between the degree of change of the artefact encompassed by the theory and the change of the theoretical boundaries driven by the design and evaluation of the artefact.

A DSR Conceptual Model

Based on the analysis in the previous sub-sections, we have developed a conceptual model consisting of categories, key constructs and relationships. We used Grounded Theory to group the key constructs into categories (e.g. Strauss and Corbin 1998). During the process of categorisation, we have followed the recommendation by Strauss and Corbin (1998) and asked the following questions: What does this concept mean? What is this about? What examples of this construct exist? What is this construct an example of? and What other constructs relate to this construct? Our conceptual model is divided into four categories: *design theory*, *kernel theory*, *design and evaluation*, and *organisational context* (see figure 4). The relationships were identified by analysing statements in the literature and we have provided a literature reference to each relationship. The purpose of the arrows is to guide the reading direction. To improve readability, we omitted implicit relationships between key constructs.

In figure 4, kernel theory is depicted as a separate category from the category of design theory. As opposed to some scholars (e.g. Walls et al. 1992; Markus et al. 2002) and in accordance with Goldkuhl (2004), we do not regard kernel theory necessarily to be included in design theories. That is, kernel theories might be included, but do not have to be included. A kernel theory consists of general explanatory theory. Such theories "… should not be seen just as a process of logical derivation" (ibid. p.68). Instead, they are used as a basis for inspiration, translation and incorporation into the design theory. The category of design theory includes constructs related to either generation of theory or validation/justification of theory. The design and evaluation category describes constructs related to the construction of the artefact. The category of organisational context includes constructs that represent instances of goals, problems and artefacts.

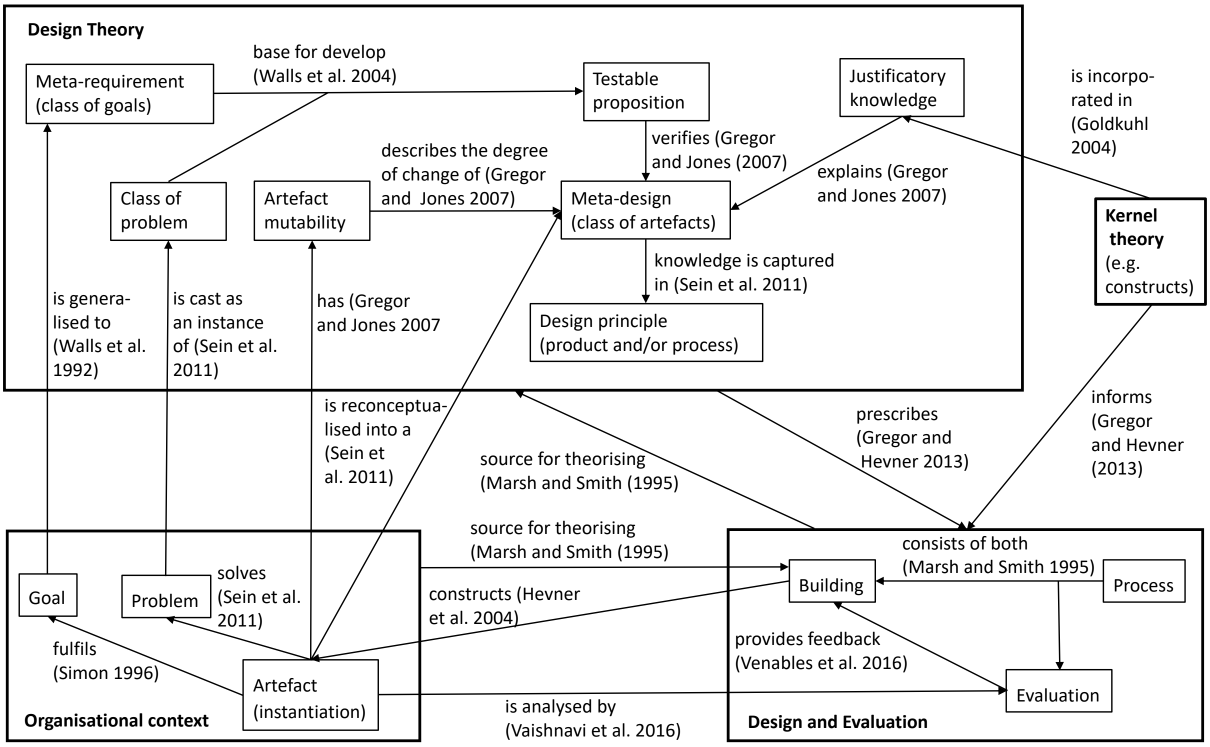

Figure 4. A conceptual model of Design Science Research

Comparison with Existing Models

The purpose of this section is to highlight the contribution of our study by comparing our model presented in the section 'A Conceptual DSR Model' with the existing models presented in the section 'The State of the Art Concerning Existing Models'.The model suggested by Walls et al. (1992) concerning relationships among ISDT components includes several important key constructs and relationships (see Figure 1). The constructs included in Walls et al. (2004) correspond to key constructs that are included in our categories 'Design theory' and 'Kernel theory'. We can conclude that the model presented by Walls et al. (1992) is missing the key constructs that are included in our categories 'Organisational context' and 'Design and Evaluation'. We acknowledge that several of the lacking constructs are discussed in Walls et al. (2004) but they are not explicitly included in the model. This means that the model presented by Walls et al. (2004) do not offer any guidance about how the categories 'Organisational context' and 'Design and Evaluation', including their key constructs, relate to other essential key constructs in DSR. Our interpretation is that the model presented by Walls et al. (2004) is focusing on constructs that are oriented towards the creation of generic and abstract design knowledge and not on design and evaluation of instantiations of artefacts that can be useful in organisational contexts. DSR emphasises both the capturing of organisational context-specific information and the creation of generic knowledge. Sein et al. (2011) regard this as a critical component and stress that DSR research is about to make a "… move from the specific-and-unique to generic-and-abstract". In order to 'move from the specific-and-unique to generic-and-abstract', we need knowledge about both 'the specific-and-unique' and 'the generic-and-abstract'. Consequently, our model also includes the categories 'organisational context' and 'design and evaluation' which are oriented towards the instance of the artefact. This means that our model extends the model presented by Walls et al. (2004) by also providing guidance about how the 'instance-level' relates to the 'generic-level'.

One purpose of the model presented by Kuechler and Vaishnavi (2008) is to clarify the relationships between kernel theories, mid-range theories and design theories. Another purpose is to explain the differences between explanatory and prescriptive statements. Kuechler and Vaishnavi (2008) are focusing on the relationship *between different types of theories*. We can conclude that the model suggested by Kuechler and Vaishnavi (2008) complements our model since it contributes to an understanding of how explanatory theories relate to prescriptive theories. Despite that Kuechler and

Vaishnavi (2008) present several essential points of IS design research, design theory is in their model presented as an abstract construct. In our model, the construct of design theory is regarded as a category consisting of several key constructs. The purpose of the break-down of the construct of the design theory is to make it less abstract and thus make DSR easier to grasp. Another difference is that our model includes the organisational context which is excluded in the model presented by Kuechler and Vaishnavi (2008).

One purpose of the framework presented by Hevner et al. (2004) is to support an understanding of IS Research that combines behavioural science and design science paradigms. The model suggested by Hevner et al. (2004) consists of three main categories: 'Environment', 'IS research' and 'Knowledge Base'. Overall the 'Environment' corresponds to our category 'Organisational context' and 'IS Research' corresponds to our category 'Design and Evaluation'. With respect to our categories 'Design theory' and 'Kernel theory,' our interpretation is that 'Design theory' are included in IS research and just called 'Theories' while 'Kernel theories' are included in the 'Knowledge Base' and also called 'Theories'. We can also conclude that several key constructs are omitted in the model by Hevner et al. (2004) (e.g. the key constructs included in our category 'Design theory'. This means that the model suggested by Hevner et al. (2004) does not provide any guidance concerning how these key constructs relate to their three overarching categories. We acknowledge that the model suggested by Hevner et al. (2004) illustrates DSR in a simple and straight forward way which is many times preferable. However, DSR is a complex phenomenon and presenting DSR in a too simplistic manner can hide essential issues and thus obstruct a more in-depth understanding. We regard the model presented by Hevner et al. (2004) as an excellent complement to our model. Besides the individual comparisons to the existing models, we can conclude that our model extends these models by presenting a transparent categorisation of key constructs including relationships between categories and between key constructs. We can also conclude that DSR is a complex phenomenon that includes several constructs. On the contrary to the models above, our model includes a richer wholeness of constructs and relationships.

Conclusion

We can conclude that DSR is a complex phenomenon that includes a large number of constructs. The contribution of this study is a conceptual model that presents DSR key constructs. We claim that our study has advanced existing models by offering a categorisation of key constructs including relationships between categories and between key constructs. The purpose of the model is to support an understanding of DSR that helps researchers to execute, evaluate or position DSR research. We also hope that other model can support communication between researchers in DSR projects. The conceptual model is based on a literature review and thus informed by theory. We have also identified the other models discussed in the paper also are based on theoretical insights. Consequently, as future research, we suggest an empirical evaluation of our model. This can be done by interviewing researchers who have experience from DSR projects and collection of their comments in relation to our model.

References

Chandra, L., Seidel, S., and Gregor, S. 2015. "Prescriptive knowledge in IS research: Conceptualizing design principles in terms of materiality, action, and boundary conditions", in *System Sciences (HICSS)*, 2015 48th Hawaii International Conference, pp. 4039-4048.

Cronholm S, and Göbel H. 2018. "Guidelines Supporting the Formulation of Design Principles". In proceedings of *29th Australasian Conference on Information Systems (ACIS).* Sydney, Australia, Dec 3-5.

Goldkuhl, G. 2004. "Design Theories in Information Systems – A Need for Multi-Grounding", *Journal of Information Technology Theory and Application (JITTA),* (6:2), pp 59-72.

Goldkuhl, G. 2018. "Governance of shared digital artifacts in the public sector: A multi-dimensional approach". Presented at the *15th Scandinavian Workshop on E-Government (SWEG-2018)*, Copenhagen.

Gregor, S. 2006. "The Nature of Theory in Information Systems," MIS Quarterly (30:3), pp. 611-642.

Gregor, S., and Hevner, A. R. 2013. "Positioning and presenting design science research for maximum impact", *MIS Quarterly*, (37:2), pp 337-355.

Gregor, S., and Iivari, J. 2007. "Designing for mutability in information systems artifacts", *Information Systems Foundations: Theory, Representation and Reality*, pp 3-24.

Gregor, S., and Jones, D. 2007. “The anatomy of a design theory”, *Journal of the Association for Information Systems*, (8:5), p 312.

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

Hevner, A., and Chatterjee, S. 2010. *Design Research in Information Systems*. New York: Springer Publishing.

Hevner, A. March, S. T., Park, J., and Ram, S. 2004. “Design Science in Information Systems Research”. *MIS Quarterly* (28:1), pp 75-105.

Iivari, J., 2007. “A Paradigmatic Analysis of Information Systems as a Design Science”, *Scandinavian Journal of Information Systems* (19:2), pp 39-63.

Kuechler, W., and Vaishnavi, V. 2008. “The Emergence of Design Science Research in Information Systems in North America,” *Journal of Design Research* (7:1), pp. 1-16.

March S T and Smith G. 1995. “Design and Natural Science Research on Information Technologies”, *Decision Support Systems*, (15:4), pp 251-266.

Markus, M. L., Majchrzak, A., and Gasser, L. 2002. “A design theory for systems that support emergent knowledge processes”, *MIS Quarterly*, pp 179-212.

Purao, S. (2002). “Design research in the technology of information systems: Truth or dare”. GSU Department of CIS Working Paper, pp 45-77.

Schön, D. A. The Reflective Practitioner: How Professionals Think in Action, Basic Books, New York, 1983.

Sein, M.K., Henfridsson, O., Purao, S., Rossi, M., and Lindgren, R. 2011. “Action Design Research”. *MIS Quarterly*, (35:1), pp 37-56

Simon, H.A. 1996. *The Sciences of the Artificial*, 3rd edition, Cambridge, MA: MIT Press,

Strauss, A., and Corbin, J. 1998. Basics of qualitative research: Procedures and techniques for developing grounded theory. Thousand Oaks, CA: Sage.

Vaishnavi, V., and Kuechler, W. 2004. “Design science research in information systems”, AISNet. Association for Information Systems, Atlanta, Georgia, USA. January 20, 2004, http://desrist.org/desrist/content/design-science-research-in-information-systems.pdf (Retrieved January 10, 2019)

Van Aken, J. 2004, “Management Research Based on the Paradigm of the Design Sciences: The Quest for Field-tested and Grounded Technological Rules”, *Journal of Management Studies*, (41:2), pp 219-246.

Van den Akker, J. 1999. “Principles and methods of development research”. *Design approaches and tools in education and training*, pp 1–14. Springer.

Venable, J. 2006. “The role of theory and theorising in design science research”, in Proceedings of the *1st International Conference on Design Science in Information Systems and Technology (DESRIST 2006)* (pp. 1-18).

Venable, J., and Baskerville, R. (2012). "Eating Our Own Cooking: Toward a More Rigorous Design Science of Research Methods", *Electronic Journal of Business Research Methods*, (10:2), pp 141-153.

Venable, J., Pries-Heje, J., and Baskerville, R. (2016). “FEDS: a framework for evaluation in design science research”, *European Journal of Information Systems*, (25:1), pp 77-89.

Walls, J.G., Widmeyer, G.R., and El Sawy, O.A. 1992. “Building an Information Systems Design Theory for Vigilant EIS”, *Information Systems Research* (3:1), pp. 36-59.

Walls, J.G., Widmeyer, G.R., and El Sawy, O.A. 2004. “Assessing information system design theory in perspective: how useful was our 1992 initial rendition?”, *Journal of Information Technology Theory and Application (JITTA),* (6:2), p 43.

Wand, Y., and Weber, R. 2002. “Research commentary: information systems and conceptual modeling—a research agenda”, *Information systems research*, (13:4), pp 363-376.

Webster, J., and Watson, R. T. 2002. “Analyzing the past to prepare for the future: Writing a literature review”, *MIS Quarterly*, (26:2), pp. xiii-xxiii.

Winter, R. 200). “Design science research in Europe”. *European Journal of Information Systems*, (17:5), pp 470-475.