Design Science Research as Research Approach in Doctoral Studies

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Abstract

Since the use of design science research (DSR) gained momentum as a research approach in information systems (IS), the adoption of a DSR approach in postgraduate studies became more acceptable. This paper reflects on a study to investigate how a selection of IS doctoral students conducted their research and why they used DSR. The study focussed in particular on the topics of the theses, the artefacts produced, the research designs followed, the motivation for selecting DSR and the students' experience in using DSR. The study found that the cyclic nature and the relevance aspects were DSR's strengths when developing artefacts, but that discourse is still needed on the philosophical underpinnings. An alignment between the motivation to use DSR and the benefits of applying the approach was also found. This paper contributes mainly towards our understanding of the challenges and advantages when using DSR as a research approach for postgraduate studies.

Keywords

Design science research, information systems, research design, research approach/process, postgraduate studies, supervision.

Introduction

Simon (1996) introduced the idea of *designing* artificial objects where the goal specifies the design. This process is in contrast with that of natural phenomena that evolve based on natural laws. Since 1996 several publications focused on the need of more relevant research into design. In 2004 the use of design science research (DSR) gained momentum as a research approach in information systems (IS), with the publication of Hevner et al. (2004) in MISQ and the introduction of DSR by Vaishnavi et al. (2004) on the AIS web site hosted by DESRIST.org.

Design is both a *process* (a set of activities) and a product (*artefact*) (Walls et al. 1992), and supports a *problem-solving paradigm*, shifting between the perspectives of the design processes and those of the designed artefacts on a continuous basis (Hevner et al. 2004). A distinction should however be made between routine design, or system building, and research, specifically DSR. Routine design is the application of existing knowledge to organisational problems using 'best practice' artefacts. Research can be loosely defined as an activity that contributes to the *understanding* of a phenomenon and for the researcher to increase his/her knowledge. Research involves a systematic inquiry to discover, analyse, describe, understand, explain, criticise, predict and control the observed phenomenon. 'Systematic inquiry' suggests that research is based on logical relationships and not just beliefs (Ghauri et al. 2010; Saunders et al. 2009). In contrast to design in general, where the design process can be arbitrary, the main requirements on DSR therefore is that of relevance and rigour (Benbasat et al. 1999; Hevner et al. 2004).

The use of a DSR approach for the design and development of artefacts in postgraduate studies in IS also gained momentum since 2004. Several of these studies used the cyclic approach suggested by Vaishnavi et al. (2004), however, in discussions with supervisors it was suggested that students use this process in different ways in their studies, or follow other processes than that of Vaishnavi et al. (2004).

Current literature focusing on DSR includes discussions on the use of DSR, the importance of rigour and relevance, types of artefacts and the difference between design science and design research. However, not much is written on the type of artefacts produced in IS, the underlying philosophy and methods used, the reason for selecting DSR, and how students experience the use of DSR in post graduate studies

This paper addresses the gap in the literature on how students experience the use of DSR in a research study and how they implement DSR as research approach. The research question that guided this research was 'what are the type of artefacts produced, the research designs followed, the motivation for selecting DSR as research approach, and the students' experience in using DSR as research approach in IS PhDs'. The data collection, discussion and associated findings therefore specifically focuses on the topics of the theses, the artefacts produced, the research designs followed, the motivation for selecting DSR as research approach, and the students' experience in using DSR as research approach.

The paper first includes some background information on the nature of DSR and the use of DSR by PhD students. This is followed by an overview of the research method used to collect and analyse the data, and summary of the data collected. We conclude the paper with a brief discussion of the findings, including a set of guidelines that could be used by the PhD student considering DSR as research approach.

The Nature of Design Science Research

As conceptualised by Simon (1996), DSR supports a pragmatic research paradigm that is proactive with respect to technology. It calls for the creation of innovative artefacts to solve real-world problems. DSR used in the context of IS focuses on creating and evaluating innovative IS artefacts that enable organisations to address important information-related tasks (Hevner et al. 2004). DSR addresses unsolved problems in distinctive or innovative ways, or solved problems in more efficient ways. This is in contrast to behavioural science research that takes technology as a given, focusing on developing and justifying theories that explain and predict phenomena related to the use of IS technologies/artefacts and their acquisition, implementation and management. March et al. (1995) similarly argue that building and evaluating IS artefacts is based on a DSR intent, whilst theorizing (not to be confused with theory as an artefact) and justifying is based on a natural science intent (as opposed to the behavioural science intent put forward by Hevner et al. (2004)).

Vaishnavi et al. (2004) argues that the philosophical perspective of the DSR researcher changes as progress is made iteratively through the phases. Carlsson (2005) critique the view of Vaishnavi et al. (2004) and states that the authors probably mean that a researcher's knowledge of the world changes, which is a different matter. Furthermore, Carlsson (2005) points out some limitations and weaknesses in the current IS DSR frameworks, and suggests that critical realism should rather be considered as a philosophical underpinning for IS design science research. In contrast Goldkuhl (2012) investigated pragmatism and its epistemological foundations as candidate paradigm design research.

From the discussion above there is strong evidence that there is not yet agreement on a single/primary underlying research philosophy driving DSR, and a wide spectrum of underlying philosophies and associated research methods are consequently used in DSR efforts. There is, however, agreement that the main requirements on DSR is that of relevance and rigour (Benbasat et al. 1999; Hevner et al. 2004).

In order to support the requirement of relevance, the outcome of DSR should have a clear contribution to the archival knowledge base of fundamental assumptions and methodologies. According to Iivari (2007) knowledge contributions in DSR can be grouped into three main classes, namely *conceptual knowledge* (e.g. classifications, taxonomies, concepts, conceptual frameworks), *descriptive knowledge* (e.g. observational facts, empirical regularities, theories or hypotheses, natural laws) and *prescriptive knowledge* (e.g. methods, design product, design process knowledge). March et al. (1995), likewise, identified two dimensions to IS research. The first dimension, research outputs, is based on the DSR outputs or artefacts, including *constructs, models, methods* and *instantiations*. Purao (2002) and Rossi et al. (2003) added a fifth output to that of March et al. (1995), namely *better theories*. Hevner et al. (2004)

lists seven guidelines for DSR in IS research, with the first guideline referring to a viable artefact in the form of a *construct*, a *model*, a *method,* or an *instantiation*. Hevner et al. (2004)'s second guideline leans more to instantiation though, with a reference to *technology-based solutions*. Our view corresponds more with Carlsson (2005) that claimed that not only *instantiations* are included in the definition of the information systems artefact but also *constructs*, *models* and *methods* applied to IS. Therefore, in addition to these artefact types, we added another artefact type, namely that of a *framework*, representing both a model and a closely interrelated method to use/implement the model.

In order to support the requirement of rigour, several DSR processes have been proposed over time. The second dimension identified by March et al. (1995), for example, is related to research activities, based on broad types of design science and natural science research activities, including *build, evaluate, theorise* and *justify*. Several DSR related processes have been proposed over time. These include, for example, those by Takeda et al. (1990), Nunamaker et al. (1991), March et al. (1995), Purao (2002), Vaishnavi et al. (2004), Hevner et al. (2004), Peffers et al. (2007), and Offermann et al. (2009). The vast majority of these DSR processes have three common threads: identifying the problem for which a solution is to be found, designing/building the artefact that represents a solution to the problem, and evaluating the artefact.

The process of doing a doctorate is not a trivial task and there are numerous guidelines, books and publications guiding the student on the research design for doing a PhD, including topics such as the motivation to do the PhD, the supervisor, the literature review, the structure of the thesis, etc. Large portions of guiding text also include the research design aspects of the thesis and include topics such as the philosophy followed, data collection and data analysis techniques available. In IS the accepted format for writing a thesis includes a chapter on the research design.

Included in the research design is the philosophy on which the research is grounded. Trochim (2005) notes that he has seen "many a graduate student get lost in the maze of philosophical assumptions that contemporary philosophers of science argue about". This problem was also highlighted in a discussion with Master and PhD students at the University of Pretoria, when a question was posed during their research methods course on what they experience as the most difficult part of writing the dissertation. From the 42 students, 32 (76%) indicated that one of the aspects they struggled with is the research design section, requiring them to understand different underlying research philosophies and how the adopted research fits into the different world-views. Although an informal question posed in a classroom setting, reasons for identifying the research design as an obstacle warrants further investigation, also since it echoes our experience in supervising postgraduate students.

DSR is increasingly used as research approach for doctoral (PhD) research in IS, also in South Africa (Naidoo et al. 2012). Given the diversity of approaches to and outcomes of DSR, we studied the use of DSR in recently completed doctoral theses in the IS field of study. The focus of the paper is specifically on the research design of the postgraduate study undertaken by the students and the students' experience in using DSR as research approach.

Research Method

In order to answer our research question, we focused on a selection of students that used DSR in their doctoral studies. We conducted the research from four different viewpoints including (1) the motivation for selecting DSR as research approach, (2) the research design followed, (3) the artefact produced, and (4) the students experience in using DSR as research approach (see Figure 1).

The investigation followed an interpretive approach using a questionnaire for data collection (allowing for both open-ended and multiple-choice questions and responses). Purposive sampling was used to select a group of theses to analyse. The supervisors of PhD students were asked to provide the names of students who recently completed their PhDs and who have used DSR as research approach in their studies. Invitations were sent to 25 PhD students and nine completed questionnaires were received, thus a return rate of 36%. The questionnaire responses were captured using Adobe Acrobat Forms, and due to the small sample it was possible to analyse the data using a spreadsheet. The data was anonymised and a random identification number assigned to each thesis for the presentation of the findings, other than the topic and artefact types produced (which were presented in alphabetical order based on the topic of the thesis). The investigation was exploratory and no claim is made with regards to comprehensiveness of the study.

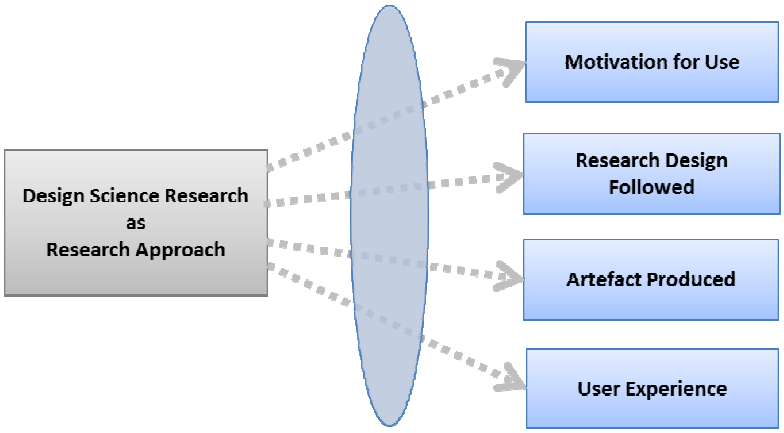

Figure 1: Research lens used

Study Findings

Topic and Type of Artefact Produced

The nine thesis topics of the sample varied considerably in subject domain, including the domains of enterprise architecture, education, knowledge management, e-health, customer information, and cloud computing and virtualization. Table 1 lists the topics and the various artefacts developed during the DSR efforts.

Thesis	Topic	Artefact Type						
		Construct	Model	Method	Framework	Instantiation	New Theory	Other
A	A Framework for valuing the quality of customer information				x			
B	A knowledge management framework for IS outsourcing							
C	A method for the selection of e-health standards to support interoperability in healthcare information systems			x				
D	A process reuse identification framework using an alignment model				x			
E	A risk and control framework for cloud computing and virtualization				x			
F	An information services framework for commercial extension services				x	x		
G	Enterprise architectonics as a conceptual device to support a fundamental understanding of enterprise architecture			x				Conceptual epistemic artefact
H	Towards a framework for executive dashboard design in a tertiary education institution	x		x	x	x		
I	Towards a framework for managing EA acceptance				x			

Table 1: Thesis topics (in alphabetical order) and artefact types produced

Instances of all the artefact types identified above, except for *new theory*, were listed. Seven of the nine doctoral studies produced a *framework* artefact. This fits with the typical relevance requirement of DSR put forward (Benbasat et al. 1999; Hevner et al. 2004), where a proposed model is supported by a method

that guides the implementation of the model. One of the study respondents indicated an artefact type that did not fit within the standard set of artefacts, calling the artefact a *conceptual/epistemic artefact*. The respondent commented that there is enough support in DSR for conceptual work, but that the reference to conceptual or epistemic artefacts is rather indirect.

Research Design Followed by the Student

Data for the *research design followed by the student* included the underlying philosophical assumptions made, the research strategy followed, the data collection and data analysis methods used, as well as the methods used to evaluate the outcome/artefact produced through the DSR process.

Thesis	Philosophy/ Philosophical Assumptions
1	Interpretive and prescriptive knowledge claims.
2	DSR paradigm and philosophical assumptions as adapted by Adebesin et al. (2011) from and Terre Blanche et al. (2006) and Vaishnavi et al. (2004): Ontology: Multiple, contextually situated realities. Epistemology: Knowing through making; context-based construction. Methodology: Developmental; impact analysis of artefact on composite system. Axiology: Control; creation; understanding.
3	Positivism.
4	Hermeneutics Heidegger's equipment analysis.
5	DSR paradigm and philosophical assumptions as adapted by Adebesin et al. (2011) from and Terre Blanche et al. (2006) and Vaishnavi et al. (2004): Ontology: Multiple, contextually situated realities. Epistemology: Knowing through making; context-based construction. Methodology: Developmental; impact analysis of artefact on composite system. Axiology: Control; creation; understanding.
6	Ontological position: Constructivist. Epistemological position: Anti-positivism. Methodology position: Nomothetic and constructive. Ethical position: Means-ends. Reasoning position: Both inductive and deductive.
7	Ontological assumption: Multiple, contextual world-states. Epistemological assumption: Knowledge obtained from discussions with experts and analyses of existing literature. Methodological assumption: The review and analyses of existing literature, discussions with professionals and experts, and the use of narratives. Axiological assumption: An understanding of the complexity of application domain.
8	Ontological assumption: Contextually situated, technologically enabled realities (world states); did not fit either the positivists' single and stable reality, nor the interpretivist' s socially constructed reality, or the critics' economic, political and cultural denominations. Epistemological assumption: Based on the concept of 'knowing through making'; a process of construction and circumscription and cyclic development. Methodological assumption: Developmental in nature. Axiological assumption: Creation of an understanding; descriptive.
9	Roy Bhaskar's critical realism. Ontological assumption: Realist. Epistemological assumption: Pragmatist.

Table 2: Philosophy used and/or philosophical assumptions made

Research Philosophy or Philosophical Assumptions

We observed above that there is no single/primary underlying research philosophy driving DSR, and a wide spectrum of underlying philosophies and associated research methods are consequently used in DSR efforts. The same variation was confirmed by our study, as presented in Table 2. Philosophical assumptions varied between typical positivist, interpretivist and critical realist approaches, to individually identified/defined philosophical assumptions to fit the specific project closely.

Research Process

All nine of the doctoral studies made use of the iterative DSR process proposed by Vaishnavi et al. (2004) as general basis for their research approach. The Vaishnavi et al. (2004) model is based on an adaptation of the computable design process model developed by Takeda et al. (1990). Although the phases in these two design process models are similar, the activities in the phases differ considerably for DSR, with knowledge contribution a key focus. The majority of the studies combined/enriched the basic research approach with the concepts from the design research guidelines proposed by Hevner et al. (2004), Hevner (2007), March et al. (1995) and Simon (1996). Since DSR is typically characterised by an iterative approach, we also asked the study participants to indicate how many iterations (cycles) of the DSR process they executed to reach their final artefact. The number of cycles utilised ranged from one complete cycle up to six cycles (one main cycle and 5 sub-cycles).

Data Collection/Analysis and Evaluation Methods

The data collection methods used by the study respondents, as presented in Table 3 (where specified), included either qualitative or both qualitative and quantitative approaches, clearly demonstrating the varied underlying philosophical assumptions that are followed in DSR. Data collection methods and analysis included interviews, appreciative inquiry, focus groups, surveys, questionnaires, dialogue analysis, statistical analysis and literature/content analysis.

Thesis	Data collection and analysis methods	Quantitative or qualitative
1	Semi-structured interviews.	Qualitative.
2	Interviews, appreciative inquiry, focus group, questionnaires. Dialogue analysis, statistical analysis, literature/content analysis.	Both qualitative and quantitative.
3	Interviews with thematic analysis of transcripts of conversations. Survey with data analysis using Excel.	Both qualitative and quantitative
4	Literature review, application of an interpretation method, analysis of industry framework, interviews.	Qualitative.
5	Questionnaire, face-to-face interviews	Both qualitative and quantitative
6	Literature review, questionnaires, interviews	Both qualitative and quantitative
7	Literature review and analysis, discussions with experts, focus groups, narratives.	Qualitative.
8	Literature analysis, interviews, questionnaires.	Both qualitative and quantitative

Table 3: Data collection and analysis methods used

Hevner et al. (2004) list five categories of evaluation methods typical deployed in DSR, including observational, analytical, experimental, testing and descriptive methods. The methods used by the study respondents, as presented in Table 4 (where specified), were mostly observational (expert reviews, demonstrations, case studies, real-world applications). Other methods used included analytical (measurement model), experimental (experiments) and descriptive (scenarios) methods.

Thesis	Evaluation method/ approach	Category
1	Expert evaluation of specification, user try-out.	Observational
2	Presentation to experts and discussion in interviews afterwards.	Observational
3	SERVQUAL instrument.	Analytical
4	Demonstration of artefact to experts.	Observational
5	Validated the framework within another industry segment.	Observational
6	Questionnaire with both closed-ended and open-ended questions based on experimentation.	Experimental
7	Descriptive evaluation using hypothetical scenarios and application in real-world project.	Descriptive Observational
8	Case study assessment.	Observational

Table 4: Evaluation methods used

Motivation for Selecting DSR as Method

The investigation also included the motivation for selecting DSR as research approach. Table 5 lists the variety of reasons provided for selecting DSR as research approach. The majority of respondents mentioned the design of an artefact to solve a particular problem and the cyclic/phased nature of the DSR process as the main reasons for selecting DSR as research approach.

Thesis	Why did you choose DSR
1	DSR was a good match for the objectives of the study. It provided a hybrid methodology between system design life cycles and research methodology.
2	The planned outcome of the research was defined as a framework artefact. The different phases of my research execution fitted well into the methodology of design research with its iterative processes
3	My research involved the creation of a framework which previously did not exist. DSR was ideally suited to the creation and evaluation of a yet to be designed or built artefact.
4	Seemed appropriate at the time of research design.
5	Identified a business problem to investigate, but did not have the answer or a hypothesis to test. A research approach where the answer could emerge as data is collected was therefore required. Initially started as action research, however the process of research that emerged was more closely suited to DSR.
6	The purpose of the study was to enhance an existing model, for which design work was required. The design process led to the development of a new artefact. Design research provides the necessary rigour for developing and evaluating novel artefacts.
7	DSR was found the most appropriate research approach, based on previous experience with the approach.
8	Based on how Hevner et al. (2004: 270) defined DSR as "a problem-solving paradigm which seeks to create innovations that define ideas, practices, technical capabilities and products through which the analysis, design, implementation, management, and use of information systems can be effectively and efficiently accomplished".
9	The respondent wanted to assist other people to solve a generic problem, i.e. not create a theory.

Table 5: Reasons for selecting the DSR approach

The students were also asked whether they considered other approaches before using DSR. Two thirds of the study respondents indicated that DSR was not the initial approach considered for their studies (see Table 6). Other approaches initially considered were action research, interpretive research and the use of mixed methods. The reasons provided for switching to DSR included realising during the research stages that DSR would be a more appropriate strategy to follow, due to its focus on developing artefacts (new solutions), being a hybrid between system development life cycles and a research methodology, and the fact that a self-designed strategy might be too complex and not recognised as appropriate or valid within the wider research community.

Thesis	DSR First	DSR Not First	If not, which other did you use as a starting point?	Why did you change?
1		x	Action research	DSR was a good match for the objectives of the study. It provided a hybrid methodology between system design life cycles and research methodology.
2		x	Interpretive research and case study	As the research progressed, the DSR approach was found to be more suitable for my research
3	x			
4		x	A self-designed method based on Heidegger's phenomenological approach to interpretation. Seemed appropriate as a first approach.	Inaccessibility if a self-designed strategy, too complex and conceptual.
5		x	Initially started with action research as it is - Iterative method for determining current situation of interest and then designing an intervention. - Researcher collaborates with practitioners and deliberately intervenes. - Contributes to both research and practice.	As the data collection cycles progressed, we realised that the eventual outcome was about solving a technical problem by developing and evaluating a new solution technology. This outcome was not aligned to action research, and DSR was adopted.
6		x	I used mixed methods, but design research was encapsulated within the mixed methods approach.	The nature of the research outputs (new artefacts) fitted within the constructivist nature of design research.
7		x	Interpretive research was considered as a potential approach at the initial stage but the research process was carried out using DSR.	As the study involved the development of a method, the DSR was found to be more suitable.
8	x			
9	x			

Table 6: Research approaches considered

Experience Using the Design Science Research Approach

We also asked participants in the study to comment on their experience in using DSR as research approach in their PhD studies. This section of the questionnaire focused on what worked well during the study, what did not work well and what was found difficult. Furthermore, we were also interested to determine if the student was satisfied with the choice that they made in selecting DSR as preferred method.

When asked to comment on what worked well in using DSR, the study respondents indicated that the logical iterative phases of the DSR process model, as proposed by Vaishnavi et al. (2004), and the DSR guidelines provided by Hevner et al. (2004) were easy to understand and provided structure to the research (see second column in Table 7). The fact that the research progression was not limited to initial assumptions was also highlighted.

Thesis	What worked well using DSR?	What did not work well using DSR?	What did you find difficult?
1	The logical application of DSR outputs and activities were understandable.	The synthesis of theory with the empirical work seemed very academic and 'artificial' and not realistic in general industry practice.	The theory synthesis.
2	DSR provided structure to my research process. The course and the cycles of my research could be described in a logical and understandable way.	Repetition of cycles takes time and effort. It would have been good to do a more in-depth evaluation of the artefact but due to time constraints (to finish the research) that was not possible.	I did not find the DSR approach difficult at all. The logical construction and description of the research process was more of a challenge.
3	Revisiting ideas and reformulating outcomes. DSR allowed my research to take shape and mould as the research progressed. I was not limited by my initial assumptions.	Identifying specific objectives of the various cycles was not always practical. Cycle iterations occasionally gained a life of its own - which is the strength of DSR.	The iterations of the various cycles frequently overlapped. It was at times confusing to remain focused on the research approach and process.
4	The means to create an conceptual artefact.	None.	DSR (and by implication ISR) does not seem to consider conceptual artefacts as artefacts, which makes the argument complex and somewhat contrived.
5	The cycle and phases defined by (Vaishnavi et al. 2004) totally supported (fit) the research approach and outcome of the research. As the cycles could be repeated as many times as what was required, it enabled the evolution of the framework until all elements were defined.	None. The respondent also commented that s/he strongly believes that if you choose DSR, you have to have a study leader with experience using this method.	It was difficult to initially understand it as I had to switch over from action research. It also impacted the order / layout of my study that was different to the 'standard'. The 'embedded' cycles concept was difficult to grasp initially as this is different to action research cycles.
6	The seven guidelines of Hevner et al. (2004) guided me in using design research, also highlighting possible deficiencies in my research approach.	It was challenging to package the thesis as one coherent study, since there were three sub-cycles within the main development step.	
7	DSR provides me with a good structure to conduct the research and write up my thesis	I struggled somewhat with the application of aspects of Vaishnavi et al. (2004) DSR process, e.g. circumscription and the abstraction of knowledge contributions.	Deciding on the appropriate number of DSR cycles/sub-cycles.
8	My thesis was well fitted to the activities of design research. The development of the framework involved primary and sub- cycles. The process of designing and developing the framework was fundamentally cyclical with multiple iterations of awareness, suggestion and development as supported by the DSR paradigm.	Difficult to consider the number of cyclical iterations required especially within sub-cycles.	Dealing with multiple sub-sets within sub-cycles.

9	Engaging with industry participants. Articulating the benefit / contribution.	Resistance from some academics to the use of DSR Negative results are scary. Not getting your artefact to work is worse than not proving your theory.	Relatively novel at the time in field of study, so examples and support was thin.

Table 7: What worked well, not well or was difficult in using a DSR approach

Varied responses were received regarding what did not work well or what was difficult in using DSR, as presented in the third and fourth columns in Table 7. The responses ranged from a mismatch between academia and industry projects, the time and effort involved in following a DSR approach, difficulty in formulating the objectives of a subsequent cycle/sub-cycle of DSR, not having a supervisor experienced in using DSR, challenges in packaging the outcomes into a coherent thesis (especially given the fact that such a thesis does not follow the traditional structure (of background, research design, data collection and analysis, and findings) of doctoral thesis promoted by the positivist and interpretivists. The different answers received confirm the comment about the resistance of some academics to the use of DSR for doctoral studies. The maturity of students in the use of DSR and the rigour required from PhD studies were also highlighted in some comments. Progressing from a masters degree, where an archival knowledge contribution is not necessarily a requirement for research, some students found the circumscription aspects and the abstraction of knowledge contributions in DSR difficult. Students also had difficulty in structuring the research process sequences and to delineate the development of the artefact into various phases.

Thesis	**Use DSR again for the same study?**	**Why**
1	No	I think I would use action design science research (Sein et al. 2011) because it seemed more practice related, organizationally focused and less bound by design science research theory.
2	Yes	DSR is a very good and structured research approach to use when any artefact is developed
3	Yes	
4	No	Perhaps I should have used a grounded theory or action research approach due to the conceptual nature of the study.
5	Yes	It was exactly the approach that the respondent wanted to follow to answer the research question.
6	Yes	A body of knowledge already exists for using DSR and is growing. Engineers are concerned with the design of new artefacts and solutions and use the design cycle by default to generate improved solutions. Yet, many engineers do not reference literature on DSR in their studies.
7	Yes	DSR is well suited to researches involving the development of 'something' e.g. methods, frameworks, etc.
8	Yes	The process of designing artefacts is fundamentally cyclical and characterised through the 'build and evaluate' cycle. My thesis entailed cycles of analysis, construction and testing, through which the framework iteratively evolved. DSR was therefore well fitted for my thesis.
9	Yes	It fits the area of 'problem solving'. It is a more natural approach than trying to force a 'scientific' theory creation/testing model onto what is essentially problem solving. The respondent left academia after completion of the PhD to work as a consultant in the area of analytics, leading a team of data scientists to work on commercial problems. DSR is basically what they do every day, so studying it formally and thinking about it deeply is very helpful.

Table 8: Why DSR will be used again

When asked whether the participants, in retrospect, would use DSR again if they had to repeat the same study, seven of the nine respondents said that they would (see Table 8). The seven were all positive about the DSR approach. The two negative responses had two opposite tones: the one commented on the rigour aspect (too much of it), whilst the second debated whether using another research approach would not have been more appropriate.

Discussion of Findings

In the remainder of this section we summarise the key findings from our investigation from the four focus areas, the motivation for selecting DSR, the research design followed, the artefact produced, and the students' experience in using DSR.

Motivation for Use of DSR

Motivation is seen as the reason why someone does something; it explains behaviour. In research projects there are a number of influences that may guide the student to select a research approach. From the data in our investigation, eight themes were identified that influenced the selection of DSR as approach:

1. DSR alignment: DSR aligned with research goals.
2. Artefact: The research output is an artefact.
3. Problem solving: The approach focuses on a problem to be solved.
4. Nature of DSR: The approach is similar to the system design approach.
5. Cycling between deductive and inductive reasoning: The approach builds iteratively towards a 'solution based on existing theories or defining 'new' theories.
6. Rigour: The process produces a theoretical contribution.
7. Relevance: The process provides a practical solution.
8. Familiarity: Used in previous projects.

Research Design

For the research design used by students, four areas were investigated that included the philosophy, process followed, data collection/analysis and evaluation. From the data collected there were coherence with regards to the specific process used, and there seems to be no problem with the process, data collection/analysis or evaluation aspects. However, different philosophical stances were used in the research including interpretivist, positivist, constructivist and critical realism stances, hermeneutics, as well as considering DSR as paradigm in its own right.

Artefact Produced

Five types of research outputs, or artefact types, are typically associated as outputs of DSR in IS research, namely *constructs, models, methods, instantiations* and *better theories*. We defined, in addition to these five, a *framework* as the combination of a model and a closely interrelated method to use the model.

User Experience

In the context of this study user experience refers how the student experienced the use of DSR as research approach in their PhD studies. Aspects that were investigated were the identification of the strengths of DSR, the weaknesses and the difficulty of using DSR (see Table 9). A contradiction was that the cyclic nature was seen as both a strength and an issue (described as 'difficult').

Strengths	Weaknesses or Difficulty to Use
- Logical application of DSR outputs. - Structure. - Phased approach. - Means to create conceptual artefact. - Hevner's guidelines valuable during the process. - Process to create artefact. - Relevance of research. - Cyclic nature.	- Misalignment of process and practice. - Time consuming. - Difficult to use concepts such as circumscription and abstraction of knowledge contributions. - Difficult to package thesis. - Resistance from academics against the use of DSR. - Cyclic nature. - Recognition of conceptual artefacts. - Limited supervision support.

Table 9: Strengths and weaknesses

Guidelines for the Use of DSR in Postgraduate Studies

As mentioned previously, the investigation was exploratory and no claim is made with regards to the comprehensiveness of the study. Further research is required to build an in-depth understanding of the complexity involved in doing DSR, and the typical interaction of the student with the research process. However, we could extract useful guidelines for students from the study. Based on the guidelines provided by Hevner et al. (2004) for DSR research in IS and the feedback provided by the students, an adapted set guidelines are suggested for a PhD student considering the use of DSR in postgraduate studies, as presented in Table 10.

Hevner et al. (2004) Guideline	Question to be Asked by PhD Student	Comment by Authors
Design as an artefact : An identifiable and viable design artefact, as in March et al. (1995), must be produced.	Is the focus of my research on the design and development of a construct, model, method, instantiation, better theory, or framework?	IS research often produces and use *frameworks*. A framework as an artefact type was therefore added.
Problem relevance: The design must address a relevant and important problem.	Why is my development of the new (or adapted) artefact relevant? Who will use this artefact? Is this an important problem to find a solution for and why is it important?	Depending on the type of artefact it is sometimes easier to show relevance.
Design evaluation: The utility, quality, and efficacy of the design artefact must be rigorously evaluated.	How will the artefact be evaluated for its practical use, quality, and capacity to produce the desired outcome?	In DSR that is based on the use of extensive grounded theory during the inductive DSR phases, time scales may be a problem and limit the evaluation of the proposed artefact.
Research contributions: The contribution must be clear and verifiable.	If my artefact is to be relevant, what is my research contribution and what does it contribute to the theory base in IS?	
Research rigour: Research methods must be rigorously applied.	What is my research philosophy, my research approach (strategy) and how will I collect data and analyse the data during research?	Graphically representing the research process followed during the development and evaluation of the artefact may assist the student in the research rigour.

Design as a search process: Searching for an effective artefact requires various means to reach desired ends within the laws in the problem environment.	Why is the DSR generate/test cycle appropriate for my research and the development of my artefact? What value is added by using DSR in my problem environment in comparison with other approaches?	There still exists some resistance to DSR as valid research approach in IS.
Communication of the research: Presentation of results should address rigour and relevance.	Who in the IS community will find my research appropriate? Who in industry would use the developed artefact?	Depending on the type of artefact it is sometimes easier to present the outcome of DSR to a technology-oriented audience than a management-oriented audience, and vice versa.

Table 10: Guidelines for the use of DSR in postgraduate studies

Conclusion

Although it is 11 years since the acceptance of DSR gained momentum as a research approach in IS research, the documentation of the experience of postgraduate students that adopted DSR is still lacking. Our investigation into the use of DSR from a student perspective identified the strength of DSR to be the structured cyclic nature of DSR when developing an artefact, whilst the phased approach provided additional structure to the students' research activities. The relevance of the artefact was also identified as a major theme. We also found an alignment between the motivation to use DSR and the benefits of applying the approach. Drawing on the DSR guidelines of Hevner et al. (2004), we extracted from our findings a set of guidelines for the use of DSR, which can guide the PhD student who considers using DSR in his/her studies. With regards to further research, discourse is still needed on especially the philosophical underpinning of the DSR approach. From our study and the arguments listed on what the philosophical nature of DSR is, it is evident that the previous experiences and type of research conducted by the student could play a deciding role in the philosophical approach selected.

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