DEVELOPING AN IS-IMPACT DECISION TOOL: A LITERATURE BASED DESIGN SCIENCE ROADMAP

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Abstract

This paper derives from research-in-progress intending both Design Research (DR) and Design Science (DS) outputs; the former a management decision tool based in IS-Impact (Gable et al. 2008) kernel theory; the latter being methodological learnings deriving from synthesis of the literature and reflection on the DR 'case study' experience.

The paper introduces a generic, detailed and pragmatic DS 'Research Roadmap' or methodology, deriving at this stage primarily from synthesis and harmonization of relevant concepts identified through systematic archival analysis of related literature. The scope of the Roadmap too has been influenced by the parallel study aim to undertake DR applying and further evolving the Roadmap.

The Roadmap is presented in attention to the dearth of detailed guidance available to novice Researchers in Design Science Research (DSR), and though preliminary, is expected to evolve and gradually be substantiated through experience of its application. A key distinction of the Roadmap from other DSR methods is its breadth of coverage of published DSR concepts and activities; its detail and scope. It represents a useful synthesis and integration of otherwise highly disparate DSR-related concepts.

Keywords: Design Science, Design Science research methodology, Design Science research Roadmap, Design Research, Information System Design Theory, Archival Analysis, IS-Impact

1 Introduction

This paper derives from research-in-progress intending both Design Research (DR) and Design Science (DS) outputs[1]; the former a management decision tool based in IS-Impact (Gable et al. 2008) kernel theory; the latter being methodological learnings deriving from synthesis of the literature and reflection on the DR 'case study' experience.

Recent research has yielded the IS-Impact measurement model (Gable, Sedera, & Chan, 2008), possibly the most extensively validated index for scoring operational administrative Information Systems (IS) in organisations. Petter, DeLone and McLean (2008, p. 256) suggest "[IS-Impact] has proven to be a valid and reliable step toward improved IS success measurement and either their instrument or their approach for creating and validating instruments should be adopted and further tested in different contexts." Gable et al. argue that IS-Impact yields scores on IS quality and impact that are comparable across time, parts of the organisation, and even across applications and organisations, and define IS-Impact as "a measure at a point in time of the stream of net benefits from the IS, to date and anticipated, as perceived by all key user groups" (p.381).

While the advent of a validated index such as IS-Impact is promising, and the model seemingly simple, the practical interpretation of model scores proves complex. Beyond model scores it is important to consider the interrelationships between IS-Impact model measures, dimensions, halves and index, with: stakeholder perspective, lifecycle stage, and other application demographics, as well as organisational demographics. These factors can interact in ways that are difficult to anticipate in static reports. Further, the relative importance and influence of these factors can vary with context and decision purpose. It is thus believed a dynamic, possibly expert-system based decision tool that cumulates model data, combined with context meta-data, and that allows sensitivity analysis with differential weighting of factors, will better guide management and yield insights from the data otherwise not possible.

With the intent of Design Research to yield the aforementioned decision tool, the Design Science Research (DSR) literature was reviewed, quickly revealing DSR to yet be in its genesis; there existing little consensus on fundamental related notions - e.g. DSR methods (Winter, 2008). Little effort has been made thus far to consolidate and synthesize the collective knowledge of DSR methodology. One set of guidelines by Hevner et al. (2004) has been widely cited, there being common concern however with their high-level and lack of specificity. Archival analysis by Indulska and Recker (2008) of papers reporting studies that purportedly conform to the Hevner et al. guidelines, reveals few instances of their actual application. Walls, Widmeyer and El Sawy (2004) observe that only a few papers explicitly address Information System Design Theory. Winter observes there is a "lack of a commonly accepted reference process model for design research" (2008, p. 470). Recently, Venable (2010) investigated the opinions of IS scholars on the importance of Hevner et al.'s (2004) widely cited DSR guidelines, noting "extensive disagreement on what guideline areas should be used as criteria and standards for evaluation" (p. 121) of DSR research, implying that either the existing guidelines/steps are not sufficiently clear, or they are at too high a level of abstraction and hence difficult to interpret and implement by apprentice researchers. Consequently, pragmatic guidance for novice DSR researchers is spotty and often conflicting.

Being novice design science researchers (at least in the formal sense), the authors ascertained a need to precede the intended Design Research (the Decision Tool) with the drafting of a preliminary Design Science Research Roadmap or methodology; then subsequently as reflective researchers, to test and evolve the roadmap through experience of its application in decision tool design and development.

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1 DSR in IS can be seen as one or both of two types: (1) IS design science and (2) IS design research. Winter (2008, p. 471) makes the distinction between these two types stating: "While design research is aimed at creating solutions to specific classes of relevant problems by using a rigorous construction and evaluation process, design science reflects on the design research process and aims at creating standards for its rigour". Kuechler and Vaishnavi (2008) have a similar view, and see DSR in the IS field as, research with design as either a topic or method of investigation. Goldkuhl and Lind (2010) also propose a comparable distinction, dividing DSR into meta-design practice and design practice.

In summary, aligned goals of this research-in-progress are: (1) to make a Design Research (DR) contribution through the design and development of an IS-Impact Decision Tool, having the IS-Impact measurement model as kernel theory; and (2) with the aim of making a Design Science (DS) methodological contribution, to iteratively and reflectively evolve the DSR methodology employed in tool development, comprehensively accounting for contemporary DSR literature and treating development of the tool as a DSR case study.

This paper focuses on drafting the preliminary structured roadmap, drawing exclusively on existing DSR literature. Drawing solely on the literature, without at this stage making specific reference to the intended decision tool, it is hoped the draft Roadmap will have broad relevance. The rest of the paper is organized as follows. First, we describe the process employed for literature analysis of past DSR. We then present the Roadmap synthesized from the literature.

2 Methodology

The Roadmap was built on existing DSR literature. Highly cited DSR papers such as (Hevner, March, Park, & Ram, 2004; S.T. March & Smith, 1995) identified using search terms like 'Design Science Methodology in IS'; and checked against Google scholar statistics [2] formed the first layer of input to the study. The pool of papers were then extended, based on backward and forward searching (Webster & Watson, 2002), peer recommendations and the inclusion of related special issues (e.g. 2008 MIS Quarterly vol. 32 no.4) and specialist conference proceedings (e.g. DESRIST). Only papers that had a clear methodological contribution and others that had indirect methodological contribution were selected as input for the Roadmap derivation, resulting with 60 key articles (a list of the full set of 60 papers is available from the 1st author of which (only)15 contained some form of methodological guidance).

In order to accomplish literature analysis, Nvivo 8.0 software was used as a qualitative data analysis and management tool in this study, following guidelines presented by (Bandara, 2006; Gregorio, 2000). Key concepts were captured within specified categories (as nodes) and expanded into sub sections via multi level coding branches (tree nodes). A glossary of key terms and definitions of DSR were also captured to support and augment the analysis. The work presented here is the result of the detailed analysis of the coding which were dedicated for 'DSR methods/steps', against which was mapped all material that either explicitly or implicitly suggested guidance on how to undertake DSR. The next section shows the result of synthesizing this node content.

3 Synthesis of the Design Science Roadmap

This section presents the DS Roadmap derived from the analysis of DSR methodological contributions available from the analysed literature. The overall study consists of seven main research stages that capture the overall phases that a DS researcher follows. The derivation of the Road map is only one of these stages..

The Road map, see Figure 1, is a synthesised amalgamation of the acceptable existing methodological guidelines for DSR, and is based on literature. Out of 60 articles identified in our dataset, fifteen papers explicitly propose methods to conduct DSR. Table 1, summarises these; listing detailed activities, steps or tasks distilled from these 15 key methodological DSR articles. It should be noted that some of studies are focused on only one step, such as the evaluation process, e.g. (Pries-Heje, Baskerville, & Venable, 2008b). Further notice, though two of these studies in the Table, Walls, Widmeyer, & El Sawy (1992) and Gregor & Jones (2007) which both propose the structure of a design theory as an output of DSR, are clearly not DSR activities, we believe they should be included in Table 1 because these two studies

[2] The year of publication was taken into account as advised by (Samuel-Ojo et al., 2010, p. 135).

indirectly impact DSR methodology. Put it differently, in order to build every design theory components, a researcher has to do specific activities.

The Roadmap (Figure 1) is the result of the literature analysis that shows DSR steps, from the 'spark' of a design idea through to publication; it gives a holistic blueprint for conducting DSR because it combines most aspects of DSR. It integrates Hevner et al.'s (2004) IS research framework, DSR cycles (relevance, design and rigour) (Hevner, 2007), and all of the DSR steps shown in Table 1. In addition, it adopts the Information System Design Theory (ISDT) structure proposed by (Gregor & Jones, 2007); ISDT is comprehensive because it is based on Walls et al.'s (1992) work, and includes the broadly accepted DSR outputs proposed by (S.T. March & Smith, 1995). A framework for evaluating risks in DSR proposed by (Pries-Heje, Baskerville, & Venable, 2008a) is also considered in each step of the Roadmap. The Roadmap is consistent with a multi-grounded design research process and design theory as discussed in (Goldkuhl, 2004; Goldkuhl & Lind, 2010). A Central Design Repository (CDR), where a researcher should document every aspect of the design journey, has been added to document. Since "knowledge is generated and accumulated through action. Doing something and judging the results is the general model" (Owen, 1998, p. 11), CDR should include circumstances of all successful and failed attempts while progressing the research. The CDR components are consistent with the common two design views – design as process (verb)/product (noun)[3]. A key distinction of the Roadmap from other DSR methods is its breadth of coverage of published DSR concepts and activities; its detail and scope.

More specifically[4], and with closer focus on the design cycle (around fourteen processes) of the overall DSR Roadmap, the initial spark of the design idea may come from an environmental need, the creative thinking of the designer based on experience and identified knowledge, or both. The value of a new idea may perhaps be to solve an expected or current problem, satisfy needs, or innovate something new for the environment. The designer should next investigate whether a solution already exists in either the knowledge base or practice; and evaluate the importance of the design. Given no existing solution and there is value from the design, the designer next considers the viability of the new solution by asking one question: Can it be built? If yes, the objective of the design is defined. This objective should then be inspected under the DSR lens to ensure the design is within the DSR paradigm. Should the researcher find that the design does not pass any of the above steps, s/he has to document the situation in the CDR and exit from the DSR cycle.

Once the DSR objective is defined, the researcher uses the first two differentiations proposed by Winter (2008) to determine, first, the type of research: Design Science or Design Research, and then, to define the theme of the research: construction, evaluation, or both. Next, the researcher needs to define the design requirements, possibly through empirical work. Necessary resources and skills should be specified prior to starting the design.

At this stage, the researcher can commence the design process by defining the first alternative solution, which could be supported by a kernel theory or practice, from the same or another discipline. Subsequently, the researcher prepares anything specific for this alternative, for example by specifying the evaluation metrics. The alternative solution is designed and developed, where after the solution undergoes internal evaluation where it may pass on to external evaluation or return to the design step for refinement before entering the same loop again. If the design cannot satisfy internal evaluation, the researcher moves to an alternative solution. The same loop occurs in external evaluation. The design should only go through external evaluation when it is verified and validated, because this evaluation is risky and costly.

[3] Given that an ISDT should deal with two design aspects: a designed product and a design process (Walls et al., 1992), the CDR consists of two separate parts, a designed product and a design process. The former documents knowledge about a product such as properties, structure and functions; the latter documents the process of how to perform and implement a design solution.

4 Subsequent to submission of this paper to ECIS, and in retrospect consistent with concerns expressed by the ECIS reviewers, a more detailed discussion on the Roadmap depicted in Figure 1 was included in the paper (Alturki, Gable, & Bandara, 2011).

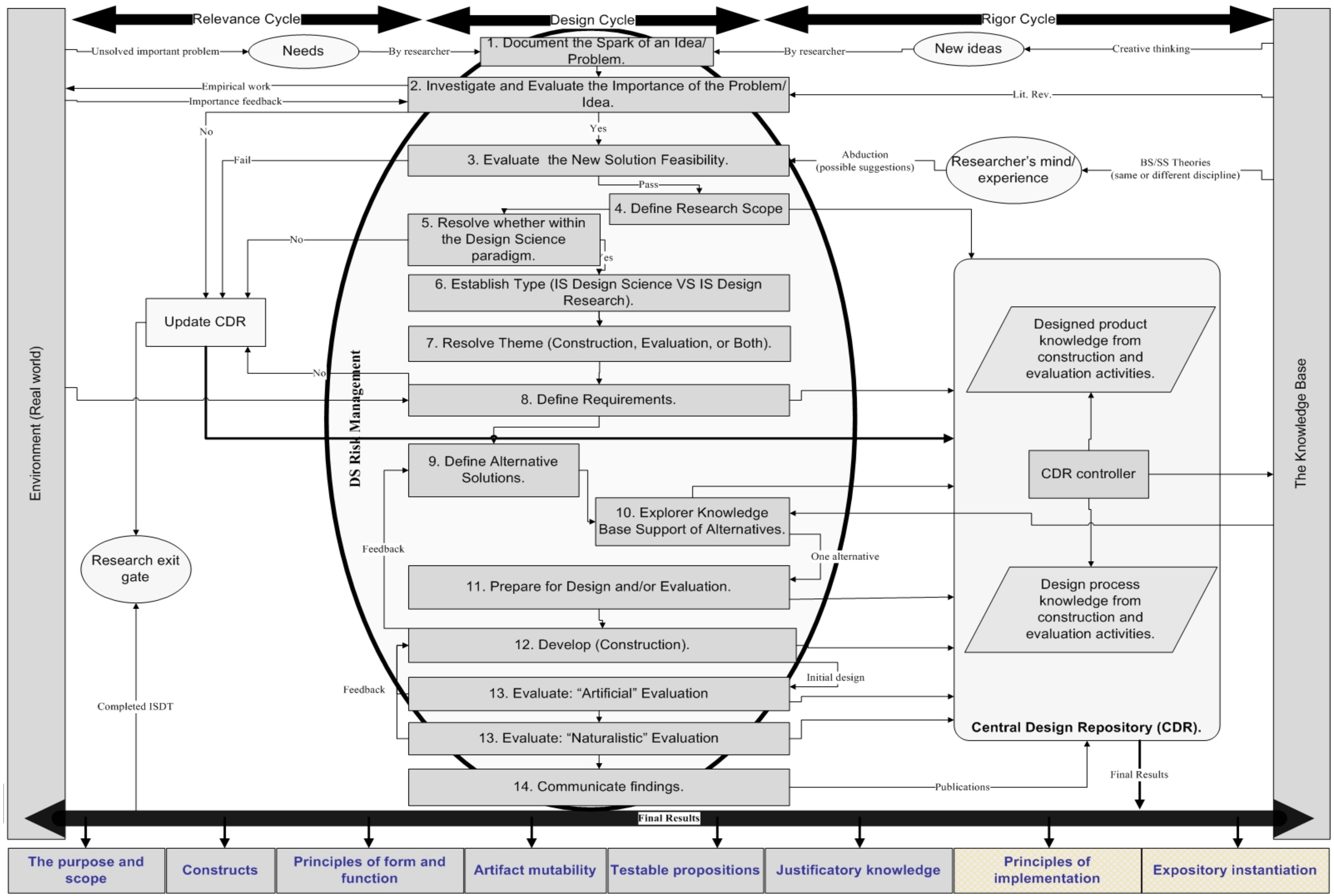

Figure 1. The overall Design Science research Roadmap

Author/Year	Steps	Design Science Activities/Steps/Tasks presented in the paper							
(Nunamaker Jr, Chen, & Purdin, 1991)	5	Construct a conceptual framework	Develop a system architecture	Analyse and design the system	Build the (prototype) system	Observe and evaluate the system			
(Walls et al., 1992)	2	Design Product				Design Process			
	7	Meta-requirements	Meta-design	Kernel theories	Testable design product hypotheses	Design method	Kernel theories	Testable design process hypotheses	
(S.T. March & Smith, 1995)	2	Build	Evaluate						
(Rossi & Sein, 2003)	5	Identify a need	Build	Evaluate	Learn	Theorise			
(Hevner et al., 2004)	7	Design as an Artifact	Problem Relevance	Design Evaluation	Research Contributions	Research Rigour	Design as a Search Process	Communication of Research	
(Vaishnavi & Kuechler, 2004)	5	Awareness of a problem	Suggestion	Development	Evaluation	Conclusion			
(Aken, 2004)	4	Choosing a case	Planning and implementing interventions	Reflecting on the results	Developing design knowledge to be tested and refined in subsequent cases				
(Cole, Purao, Rossi, & Sein, 2005)	4	Problem Definition	Intervention	Evaluation	Reflection and Learning				
(Venable, 2006)	4	Solution technology invention	Theory building	Artificial evaluation	Naturalistic evaluation				
(Peffers, Tuunanen, Rothenberger, & Chatterjee, 2007)	6	Problem identification and motivation	Define the objectives for a solution	Design and development	Demonstration	Evaluation	Communication		
(Gregor & Jones, 2007)	8	Compulsory						Optional	
		The purpose and scope	Constructs	Principles of form and function	Artifact mutability	Testable propositions	Justificatory knowledge	Principles of implementation	Expository instantiation
(Salvatore T. March & Storey, 2008)	6	Identification and clear description of a relevant organizational IT problem	Demonstration that no adequate solutions exist in the extant knowledge-base	Development and presentation of a novel IT artifact that addresses the problem	Rigorous evaluation of the IT artifact enabling the assessment of its utility	Articulation of the value added to the knowledge-base and to practice	Explanation of the implications for IT management and practice		
(Pries-Heje et al., 2008a)	4	Risk Evaluation in DS Research							
		Risk identification	Risk analysing	Risk treatment	Risk monitoring				
(Pries-Heje et al., 2008b)	8	Evaluation Activity							
		Ex Ante Naturalistic Design process	Ex Ante Naturalistic Design product	Ex Ante Artificial Design process	Ex Ante Artificial Design product	Ex Post Naturalistic Design process	Ex Post Naturalistic Design product	Ex Post Artificial Design process	Ex Post Artificial Design product
(Baskerville, Pries-Heje, & Venable, 2009)	7	A specific problem is identified and delineated	This problem must then be expressed as a specific set of requirements	The specific problem are systemically abstracted and translated into a general problem	General solution design (a class of solutions) for the general problem	General design requirements are compared with the specific problem for fit	A declarative search is then made for the specific components that will provide a workable instance of a solution to the general requirements.	An instance of the specific solution is constructed and deployed into the social system	

Table 1 Design Science Activities/Steps/Tasks Distilled from the Literature

Since the produced knowledge from the DSR comes from the construction process, everything should be documented in the CDR to accumulate the knowledge. The content of the CDR is separated into two parts. The first is the process of how to perform the solution design; the other part is about the product prosperities and functions. The CDR controller will have simple criteria to manage and be responsible for the CDR content. The content of the CDR could be published to communicate to academics and practitioners.

In this Roadmap, two parts should be considered during its progression. First, the risks must be defined, documented, and monitored for every step in the CDR. In this Roadmap, every step a researcher takes must be documented in the CDR, as shown in Figure 1. Second, the ISDT proposed in (Gregor & Jones, 2007) should be populated from the content of the CDR. This population may be gradually completed component by component during the design progression, or at one time when the design is finished.

4 Conclusion

There is strong need for detailed guidance on the conduct of DSR. This paper has proposed a highly tentative overall DSR Roadmap for such research in the IS discipline. The overall Roadmap is a general guide for novice researchers in conducting DSR, providing reasonably detailed steps. In future and specifically for the current research project, this Roadmap will be translated to a situated method to undertake the IS-Impact Tool development as a construction blueprint. Learnings from the IS-Impact Tool development will advance and test the Roadmap utility, parsimony, appropriate hierarchy and completeness, treating the IS-Impact Tool development as a case study of the Roadmap application. The DSR roadmap contributes to both researchers and practitioners. The overall DSR Roadmap appears to have wide application. For instance, researchers can create a situational instance of the Roadmap for their DSR. They can also alter the situated version to fit any specific design requirements. Obviously, the Roadmap has direct or indirect impact on academy and practice.

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