Validating The Design Science Research Roadmap: Through The Lens Of “The Idealised Model For Theory Development”

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VALIDATING THE DESIGN SCIENCE RESEARCH ROADMAP: THROUGH THE LENS OF “THE IDEALISED MODEL FOR THEORY DEVELOPMENT”

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Abstract

Design Science Research (DSR) has emerged as an important approach in Information Systems (IS) research. However, DSR is still in its genesis and has yet to achieve consensus on even the fundamentals, such as what methodology/approach to use for DSR. While there has been much effort to establish DSR methodologies, a complete, holistic and validated approach for the conduct of DSR to guide IS researchers (especially novice researchers) is yet to be established. Alturki et al. (2011) present a DSR ‘Roadmap’, making the claim that it is a complete and comprehensive guide for conducting DSR. This paper aims to further assess this Roadmap, by positioning it against the ‘Idealized Model for Theory Development’ (IM4TD) (Fischer & Gregor, 2011). The IM4TD highlights the role of discovery and justification and forms of reasoning to progress in theory development. Fischer and Gregor (2011) have applied IM4TD’s hypothetico-deductive method to analyze DSR methodologies, which is adopted in this study to deductively validate the Alturki et al. (2011) Roadmap. The results suggest that the Roadmap adheres to the IM4TD, is reasonably complete, overcomes most shortcomings identified in other DSR methodologies and also highlights valuable refinements that should be considered within the IM4TD.

Key words: Design Science Research Methodology, Roadmap for Design Science Research, Idealized Model for Theory Development, Information Systems.
1 INTRODUCTION

Design Science Research (DSR) can be defined as “attempts to create things that serve human purposes” and entails “devising artifacts to attain goals” (Simon, 1996, p. 55). Iivari and Venable (2009, p. 4) believe DSR is a “research activity that invents or builds new, innovative artefacts for solving problems or achieving improvements, i.e. DSR creates new means for achieving some general (unsituated) goal, as its major research contributions. Such new and innovative artifacts create new reality, rather than explaining existing reality or helping to make sense of it”.

The importance of DSR has been established (Iivari, 2007; Kuechler & Vaishnavi, 2008), with its prominence growing rapidly in the Information Systems (IS) discipline (Goldkuhl & Lind, 2010). Regardless, consensus on the fundamentals of DSR (e.g. methodology, outputs) has yet to be achieved (Winter, 2008), reflecting the relative recent emergence of this research paradigm in IS (Iivari & Venable, 2009; Kuechler & Vaishnavi, 2008).

While there has been much effort to establish a DSR methodology (e.g. (Hevner, March, Park, & Ram, 2004; Peffers, Tuunanen, Rothenberger, & Chatterjee, 2007)) a holistic, validated and widely accepted approach for its conduct is lacking. Views and prescriptions on the methodology of DSR are disparate, e.g. (Baskerville, Pries-Heje, & Venable, 2009; Hevner, 2007; Järvinen, 2007; March & Smith, 1995; March & Storey, 2008; Nunamaker Jr, Chen, & Purdin, 1991; Peffers, et al., 2007; Vaishnavi & Kuechler, 2004; Venable, 2006a), with few papers mentioning Design Theory (Walls, Widmeyer, & El Sawy, 2004) as originally proposed by Walls et al. (Walls, Widmeyer, & El Sawy, 1992), and few applying in full (Indulska & Recker, 2008) the widely cited guidelines by Hevner et al.(2004). There is “extensive disagreement on what guideline areas should be used as criteria and standards for evaluation [of DSR]” (Venable, 2010, p. 14). Thus there is a need for, and potential value from, a detailed and more specific methodology that is prescriptive yet scientific.

To address this need, Alturki et al. (2011) presented a holistic DSR methodology; a DSR Roadmap which provides researchers (especially novices) with detailed steps (and supporting components) for conducting DSR. Their Roadmap arose from a synthesis through content analysis of related methodological writings in recognized IS outlets. Alturki et al. (2011) state that the Roadmap is tentative and expected to evolve with critique over time.

In parallel with the Roadmap’s appearance, Fischer and Gregor (2011) proposed an ‘Idealized Model for Theory Development’ (IM4TD) which suggests how scientific knowledge is developed. They distinguish between the contexts of Discovery and Justification, and then propose and position three forms of reasoning within these two contexts. Fischer and Gregor (2011) demonstrate that their model can be revealing when used to examine and validate DSR methods in Information Systems (IS). They examine four popular IS DSR methods and identify several shortcomings (further related detail is provided in subsequent sections).

In essence the IM4TD is a high-level process model of how theory develops across the two main contexts of Discovery and Justification, emphasizing the role of different forms of reasoning across the contexts, and highlighting the under-appreciated role of abduction in Discovery. It is implied that this process model is generalisable to all hypothetico-deductive paradigms and methodologies. If one accepts the IM4TD, and that the Roadmap is a hypothetico-deductive methodology, then it follows that the Roadmap should conform to the IM4TD. On this basis, this paper views the Roadmap through the IM4TD lens to examine its conformance.

Thus, this paper contributes to the further evolution and validation of the Roadmap presented by Alturki et al. (2011) by applying the IM4TD as suggested by Fischer and Gregor (2011). Through this analysis, we illustrate how the Roadmap addresses and can overcome common ‘shortcomings’ in other IS DSR methodologies. Additionally, we demonstrate how the Roadmap adheres to the IM4TD, thereby further evidencing the Roadmap’s robustness and theoretical basis. Finally, viewed through the IM4TD lens, the Roadmap is found wanting in several respects, suggesting valuable enhancements. Thus, consistent with the Roadmap itself, in striving for completeness, clarity and
utility, we employ the IM4TD to deductively evaluate the Roadmap, as a part of its ongoing evaluation cycles.

Ultimately, a new, revised and enhanced version of the Roadmap is presented, resulting from its critique with respect to the hypothetico-deductive IM4TD. Additionally, the paper presents an example (additional to those examples discussed by Fischer and Gregor (2011)) of how to apply the IM4TD to examine and validate a research methodology; further demonstrating how their model can be used for validating other methodological models and frameworks in IS.

The manuscript begins by summarising the Idealized Model for Theory Development (IM4TD) (Fischer & Gregor, 2011) and its basic concepts, and the DSR Roadmap (Alturki, et al., 2011). Next, shortcomings of current IS DSR methodologies, as discussed by Fischer and Gregor (2011) are highlighted. The subsequent section examines the Roadmap through the lens of the IM4TD. The paper concludes with results from this examination.

2 BACKGROUND

2.1 Idealised Model for Theory Development

The IM4TD (Fischer & Gregor, 2011) makes a fundamental distinction between the context of Discovery (identifying and catching novelty) and the context of Justification (validation as a scientific method) - see (Hoyningen-Huene, 1987; Reichebach, 1935). The model proposes three forms of reasoning - deduction, induction and abduction, which are used in both contexts. Before we explain the model we first describe the three forms of reasoning.

2.1.1 Deductive reasoning:

Deductive reasoning derives a conclusion from generalising existing theory to specific instances (Lee, Pries-Heje, & Baskerville, 2011; Sun & Pan, 2011). Falsification, is the main mechanism of deductive reasoning, which means a “theory can only be shown to be wrong, but never be proven to be right” (Lee, et al., 2011, p. 3). Similarly Fischer and Gregor (2011) define deductive reasoning as that, where a specific conclusion can be logically deduced from one or more general theories/principles. Deductive reasoning is always firm - which means, if the theory is true, a logically deduced conclusion is necessarily true (Fischer & Gregor, 2011).

2.1.2 Inductive reasoning:

In contrast, with inductive reasoning a general proposition is formulated on the basis of a particular proposition. It means researchers make their observations based on sample instances of the population and generalise these observations to all entities of that population (Fischer & Gregor, 2011). This reasoning develops general conclusions from particular cases; it builds theories from specific instances (Lee, et al., 2011). Cited in (Sun & Pan, 2011), Schilpp (1974, p 1014) define induction as “inference from repeatedly observed instances to as yet unobserved instances”.

2.1.3 Abductive reasoning:

This type of reasoning is commonly referred to as inference to the best explanation (Aliseda, 2006; Peirce, 1931-1958). Abductive reasoning investigates observations, thereafter building theories to explain them (Sun & Pan, 2011). Abduction is a creative process and plays a vital role in introducing new ideas or hypotheses (Fischer & Gregor, 2011; Sun & Pan, 2011). It is prominent in the first step of scientific reasoning (Fischer & Gregor, 2011).

Having defined deductive, inductive and abductive reasoning for our purposes, we next explain the IM4TD. Figure 1 depicts the model, including the DSR activities/processes that contribute to scientific theory development. As the figure depicts, the model distinguishes between two contexts of knowledge advancement: the context of Discovery and the context of Justification. The three forms of
reasoning can be used in each context. Each context has unique steps within the IM4TD. The model considers empirical testing of ideas as a part of scientific activity.

![IM4TD with the DSR activities/processes that contribute to theory development](adapted from (Fischer & Gregor, 2011, p. 22))

The model starts with noticing novelty or an anomaly. This so-called ‘step zero’ is considered preparatory for DSR research; it is the ‘spark’ of a research idea. Step 1 involves mainly abductive reasoning, but could involve deductive and inductive reasoning as well. In this step, conjectures are developed. In step 2a, hypotheses are deduced from existing theories or newly postulated theories; known knowledge (deduction). Subsequently, in step 2b these hypotheses are validated empirically (induction) by observing instances or building instances as proofs of concept. While the first step relates mainly to the context of discovery, steps 2a and 2b describe the context of justification. Notably, abduction, deduction or induction could be employed in each context.

### 2.2 The Roadmap

This section briefly introduces the Roadmap and its components. The Roadmap is a structured and detailed methodology for the conduct of DSR. It is a general guide for researchers to carry out DSR by proposing reasonably detailed activities. The Roadmap usefully inter-relates many otherwise seemingly disparate, overlapping or conflicting concepts. It covers the entire DSR lifecycle, from the early ‘spark’ of a design idea, through to final publication.

Structurally, the Roadmap (see Figure 1 in (Alturki, et al., 2011)) consists of four main interrelated components: (A) Activities and Cycles; (B) Output, (ultimately, Information System Design Theory - ISDT) (Gregor & Jones, 2007); (C) Risk Management; and (D) Central Design Repository (CDR). Component (A) incrementally populates and draws from component (D) which ultimately contributes to component (B). Component (C) and Component (A) are executed in parallel, both again using component (D). Consequently, components (B) and (D) are the sources that contribute to both the environment and the knowledge-base. Each component is further explained following.

#### 2.2.1 Component A: DSR activities and cycles

This component focuses on the detailed DSR activities, and covers the main steps needed to conduct DSR. The relationships between these steps and other components of the Roadmap are presented in detail in Alturki et al. (2011). This component consists of sixteen steps commencing from how the DSR is initiated, through to the publication of DSR output [which is the adaptation of Information System Design Theory (ISDT)]. Table 1 summarizes all steps in this component.
<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Document the Spark of an Idea/Problem</td>
</tr>
<tr>
<td>2</td>
<td>Investigate and Evaluate the Importance of the Problem/Idea</td>
</tr>
<tr>
<td>3</td>
<td>Evaluate the New Solution Feasibility</td>
</tr>
<tr>
<td>4</td>
<td>Define Research Scope</td>
</tr>
<tr>
<td>5</td>
<td>Resolve Whether within the Design Science Paradigm</td>
</tr>
<tr>
<td>6</td>
<td>Establish Type (IS Design Science vs IS Design Research)</td>
</tr>
<tr>
<td>7</td>
<td>Resolve Theme (Construction, Evaluation, or Both)</td>
</tr>
<tr>
<td>8</td>
<td>Define Requirements</td>
</tr>
<tr>
<td>9</td>
<td>Define Alternative Solutions</td>
</tr>
<tr>
<td>10</td>
<td>Explore Knowledge Base for Support for Alternatives</td>
</tr>
<tr>
<td>11</td>
<td>Prepare for Design and/or Evaluation</td>
</tr>
<tr>
<td>12</td>
<td>Develop (Construction)</td>
</tr>
<tr>
<td>13</td>
<td>Evaluate</td>
</tr>
</tbody>
</table>

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1 “[D]esign research is aimed at creating solutions to specific classes of relevant problems by using a rigorous construction and evaluation process, design science reflects the design research process and aims at creating standards for its rigour” (Winter, 2008, p. 471). Kuechler and Vaishnavi (2008) have a similar view, and see DS research in the IS field as, research with design as either a topic or method of investigation; for more details see Alturki et al. (2012).
The aim of evaluation is to decide not “why” or “how”, but “how well” the artifact works (March & Smith, 1995). The new system must be verified as (1) working correctly without shortcomings, and (2) performing required functions according to the defined requirements.

### “Artificial” Evaluation

The designed solution or artifact is tested in a limited way where it may pass on to external evaluation or return to the design step for refinement before entering the same loop again (Venable, 2006a).

### “Naturalistic” Evaluation

This is the ‘real’ test where the invented designed solution or artifact is tested in a real-life setting to check its validity (Venable, 2006a), based on metrics defined in step eleven.

### Communicate Findings

Reaching this step means the design solution/artifact has passed the tests in the evaluation activity and can be published and communicated. Researchers must effectively report/communicate results, contributions, limitations, and new knowledge gained during the construction and design of the DS artifact, to communities of both researchers and practitioners. Establishing a contribution to knowledge, over what was known previously, is important.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Summary of Steps in Component A (adapted from Alturki et al. (2011))</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>“Artificial” Evaluation</td>
</tr>
<tr>
<td>15</td>
<td>“Naturalistic” Evaluation.</td>
</tr>
<tr>
<td>16</td>
<td>Communicate Findings</td>
</tr>
</tbody>
</table>

### 2.2.2 Component B: Output of the DSR

This component represents the results of DSR deriving from use of the Roadmap. Alturki et al. (2011) argue that Information System Design Theory (ISDT) (Gregor & Jones, 2007) is the ultimate and most comprehensive output of DSR. The ISDT (Gregor & Jones, 2007) consists of eight elements: (1) purpose and scope, (2) constructs, (3) principle of form and function, (4) artefact mutability, (5) testable proposition, (6) justificatory knowledge, (7) principles of implementation, and (8) expository instantiation. We return to ISDT later in the paper.

### 2.2.3 Component C: Central Design Repository (CDR)

Since DSR entails much iteration, documentation in DSR is important to codify circumstances of all successful and failed attempts, while progressing the DSR. The CDR consists of two separate parts, the design- product and the design process. The former codifies knowledge about an artifact such as properties, functions, and structure; the second part is knowledge about the process of how to build and implement a designed solution or artefact as an instantiation. The ISDT elements (Gregor & Jones, 2007) (as the output of the DSR, as depicted in the Roadmap) are incrementally populated from the content of the CDR, component by component during design progression, or at one time when the DSR is complete. The full content of the CDR or part of it could be an object for the last step in component (A), to communicate the discovered knowledge through publication.

### 2.2.4 Component D: DSR Risk Management

Risk in DSR is “a potential problem that would be detrimental to a DSR project’s success should it materialize” (Pries-Heje, Baskerville, & Venable, 2008, p. 330). Risk management in DSR relates to and overlaps with all of the Roadmap steps. Researchers/designers should be aware, define, document and monitor any possible risk associated with each step in DSR. While there are potential dangers during DSR, researchers could avoid or mitigate risks if s/he could predict them. Pries-Heje et al. (2008) propose a framework to address risk management in DSR through four tasks: (1) Risk Identification, (2) Risk Analysis, (3) Risk Treatment and (4) Risk Monitoring. We agree that Pries-Heje et al.’s work complements DSR methods and Risk Management frameworks, thus risk management is incorporated in the DSR Roadmap for completeness.

### 3 SHORTCOMINGS OF CURRENT IS DSR METHODOLOGIES

In this section, we present shortcomings observed by the authors of the IM4TD (Fischer & Gregor, 2011) and from our own further analysis in an examination of four recent IS DSR methodologies: (1) (Hevner, et al., 2004); (2) (Nunamaker Jr, et al., 1991); (3) (Peffers, et al., 2007); (4) (Takeda,
Tomiyama, Veerkamp, & Yoshikawa, 1990) and (Vaishnavi & Kuechler, 2004) with respect to the IM4TD. The goal here, besides highlighting these shortcomings, is to justify the need for a detailed IS DSR (Roadmap) that adequately addresses the concepts of the IM4TD.

We summarize several deficiencies identified. The first refers to the forms of reasoning, in which respect, most prior IS DSR methodologies are not clear. Second, with one exception (Nunamaker Jr, et al., 1991), the referent IS DSR methodologies do not mention novelty or anomaly as a starting point; rather they focus only on a problem (and not an opportunity for novelty) as the ‘spark’ (and start) of design research. A third shortcoming is there are no clear steps for design theory development, nor steps for building instantiations (prototypes). Fourth, the IS DSR methodologies do not show the role of kernel theory (prior theory) in the context of discovery. Finally, the frameworks are deficient in describing what occurs in the context of discovery. Fischer and Gregor, (2011, p. 29) state there is “little or no recognition in any single framework that the first stage of DSR can involve all of abductive, inductive and deductive thinking”. All mentioned limitations confirm the calls from scholars for a comprehensive and accepted methodology for DSR (Peffers, et al., 2007; Purao, Smith, Baldwin, Hevner, Storey, Pries-Heje, Zhu et al., 2008; Winter, 2008). This is further supported by the results observed from analysing seminal DSR efforts (Indulska & Recker, 2008; Venable, 2010; Walls, et al., 2004).

4 VALIDATING THE ROADMAP: THROUGH THE LENS OF THE IDEALISED MODEL (IM4TD)

Beyond the potential value from addressing the shortcomings mentioned above, others have argued the value of and need for a detailed DSR methodology (Patas, Milicevic, & Goeken, 2011; Purao, Smith, Baldwin, Hevner, Storey, Pries-Heje, & Zhu, 2008; Winter, 2008). While the authors believe the Alturki et al. Roadmap as published in (2011) is a firm base from which to begin addressing this need, both we and they acknowledge the need for further attention to its rigor, usefulness, clarity and completeness.

In that spirit, this paper aims to further assess the Roadmap through the IM4TD lens. Fischer and Gregor (2011, p. 29) argue that “methodological frameworks for IS DSR and ISDT building would be improved and could be better integrated if the three basic forms of reasoning and the idealized model of scientific enquiry were considered more explicitly. More specifically, it should be realized that abduction, deduction and induction are all valid modes of reasoning in artifact development and that induction should be recognized for its role in developing generalized abstract knowledge and theory.”

This section evaluates how well the Roadmap addresses core requirements posited by the IM4TD. The IM4TD lens highlights several valuable extensions to the Roadmap in consideration of the two contexts (Discovery and Justification) and the three forms of reasoning (deduction, induction and abduction), while demonstrating how the Roadmap considers and resolves several of the deficiencies observed in prior IS DSR methodologies described in Section 3.

Figure 2 Positioning the two perspectives of the Roadmap in this study.

In viewing the Roadmap through the IM4TD lens, we assume two different perspectives; see Figure 2. The first perspective is that of the Roadmap’s development, how it evolved. We assume this perspective because we believe the Roadmap itself is a designed artifact; a design output, where the derivation of the roadmap is design research. The Roadmap is a detailed methodology for the conduct of DSR. Understanding DSR as a paradigm influences construction of the Roadmap. We note that this reflection on the DSR process model (the Roadmap) development, is similar to thinking in (Goldkuhl,
2004). The second perspective is on the Roadmap’s outputs; artifacts resulting from following the Roadmap as a DSR methodology. Ultimately we aim to show that the two contexts of discovery and justification, and the three forms of reasoning (deduction, induction and abduction) are considered from both perspectives, in the Roadmap design.

We follow the same process that Fischer and Gregor (2011) used to analyse the four IS DSR methodologies with respect to their IM4TD. Table 2 summarises analysis of the Roadmap from the two perspectives (as presented above), both through the lens of the IM4TD. Columns (1) to (5) briefly describe the Roadmap with respect to the applicable forms of reasoning in each of the Discovery and Justification contexts.

Table 2 below shows that the Roadmap has considered the contexts of discovery and justification. In the discovery context, the Roadmap manifests all three forms of reasoning from both perspectives. For instance, abductive reasoning is used in the first perspective in discovering the need for a detailed methodology to conduct DSR based in the related literature. Further, some components, such as the CDR, were invented abductively to satisfy documentation needs. In the justification context, deduction and induction are mainly used. For example, some components of the Roadmap are built based in existing knowledge.

5 RESULTS FROM EXAMINING THE ROADMAP THROUGH THE IM4TD LENS

Though analysis employing the IM4TD lens suggests the Roadmap is reasonably complete, it too highlights valuable potential refinements. Analysis suggested value in differentiating and considering separately the contexts of discovery and justification, and the three forms of reasoning. This awareness points to several useful refinements as reflected in the revised Roadmap in Figure 3. Many lessons have been learned from this analysis while some relate to refinements and others confirm some of the Roadmap concepts. Lessons are summarized as follow:

A. The analysis reported herein offers some evidence of the validity of the Roadmap. Although the Roadmap was coincidentally introduced in parallel with the IM4TD (at the same conference), the Roadmap is observed to address most of the shortcomings identified by the authors of the IM4TD, in prior IS DSR methodologies. In example, while the referent IS DSR methodologies do not mention novelty or anomaly as a starting point, the Roadmap commences from alternative ‘sparks’. Also, the Roadmap has a separate step for exploring kernel theory/justificatory knowledge. Beyond attending these shortcomings, the Roadmap demonstrates good consistency with the IM4TD, thereby evidencing the Roadmap’s implicit basis in theory – the IM4TD. Nonetheless, the two perspectives on the Roadmap through the IM4TD lens (Section 4) suggest valuable potential enhancements to improve clarity, completeness, and utility; to better align with the IM4TD.

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2 Note: Fischer and Gregor (2011) do not focus on communication of results in the IM4TD or on documentation or knowledge sharing within the research process. However, documentation and knowledge sharing is important throughout a research process and records and note-taking can give a base for final communication of the results of the research.
<table>
<thead>
<tr>
<th>Viewpoints</th>
<th>Context of discovery</th>
<th>Deduction</th>
<th>Induction</th>
<th>Context of Justification</th>
<th>Deduction</th>
<th>Induction</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>It was observed from examination of the literature that there was a need for a detailed and integrated DSR methodology. The Roadmap’s content, its relationships and components were creatively built through induction (content analysis) and abduction (for instance, the idea of a CDR was conjectured to satisfy the documentation needs) which then needs to be validated.</td>
<td>At the time of Roadmap construction we did not consciously pay attention to this form of reasoning. However, we were influenced by our software engineering background. Retrospectively, we believe too that the Roadmap construction was implicitly influenced by our prior knowledge of system theory and decomposition theory of complex systems. These theories will be investigated to see if they help achieve clarity and completeness of the Roadmap. While system theory aids in the construction of independent yet interrelated components, decomposition supports aids in addressing DSR complexity.</td>
<td>The construction of the Roadmap relied heavily on content analysis of past literature.</td>
<td>Propositions can be derived concerning the Roadmap as constructed; e.g. the Roadmap will be useful to other researchers to guide DSR.</td>
<td>An expert panel and case studies will be used to evaluate the Roadmap and test propositions concerning its use. Findings will allow further refinement of the Roadmap.</td>
<td></td>
</tr>
<tr>
<td>(2)</td>
<td>See steps (1-8,12) of Figure 3. These encourage a designer to think creatively to discover problems, opportunities, or needs. Designers/researchers investigate literature looking for shortcomings and opportunities, or justificatory knowledge for their alternative designs as shown in steps (1-3) and 10 of Figure 3. In steps 1-12, designers can use examples in real-life or the literature to suggest solutions or part solutions. In step 12, deductions are made to give propositions that can be tested about the artifact’s performance; e.g., a system will allow more efficient achievement of a goal.</td>
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<td>(3)</td>
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Table 2  
Positioning the Roadmap with respect to the IM4TD

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3 For the definition of Naturalistic or Artificial please see (Venable, 2006a) or see evaluation step in (Alturki, et al., 2011)
Figure 3  The new version of the Roadmap.
B. The Roadmap in the original version has integrated and adapted Information System Design Theory (ISDT) as a core output component; ISDT is an instantiation of Design Theory. The authors believe ISDT is the final target of DSR, and thus all DSR activities should contribute to ISDT. Furthermore, based on the definitions of Design Theory (Gregor & Jones, 2007, p. 320; Walls, et al., 1992, p. 37), we argue Design Theory should echo what researchers perform during the research journey; which mirrors DSR methodology. This output component, ISDT, is centrally important because researchers should, as far as possible, anticipate what they are going to produce. In this regard, Simon (Simon, 1996) believes the final goals of design activity might not be clearly realized, but the designer could well proceed with a search guided by ‘interestingness’. A good example of how Design Theory influences and inspires DSR can be found in (Müller-Wienbergen, Müller, Seidel, & Becker, 2011). Therefore, mapping between the DSR methodology processes, and the ISDT component, with its elements, creates a strong interaction. The former develops the design knowledge and the latter codifies it in a scientific structure. In other words, design theory is the result of DSR processes. DSR methodology constructs artifacts and design theory documents the final design in terms of structure and organization, justificatory knowledge, properties, and functions. “DT [Design Theory] acts as an interface between the world and the knowledge base” (Piirainen & Briggs, 2011, p. 50). Consequently, the output component, ISDT, is essential core component in the Roadmap.

The analysis using the IM4TD confirms our stance on including ISDT as an output component in the Roadmap. Two studies (Fischer & Gregor, 2011; Piirainen & Briggs, 2011) have been published at the same time of the Roadmap’s initial appearance (Alturki, et al., 2011), which support our belief in incorporating ISDT with IS DSR methodology. Piirainen and Briggs (2011) believe that DSR methodology emulates the structure of Design Theory and claim that “the DSR methodology and DT [Design Theory] complement the DSR framework and give additional guidance” (2011, p. 50). Fischer and Gregor (2011, p. 29) has similar view as quoted above. Thus, design theory is an important component that should appear in the Roadmap.

As a result, the inclusion of Design Theory in the Roadmap will help to define all other necessary components in the Roadmap because DSR activities must be done to produce knowledge/information which in return populates the output component, ISDT. In other words, we would say every component with its elements in the Roadmap must feed at least one element of the Design Theory or part of it because the ultimate harvest of DSR is producing ISDT, or at least proving steps towards an ISDT. They are in many-to-many relationship. To make it much clear, let us assume we have two components other than design theory which make the Roadmap complete. These two components should contribute implicitly or explicitly to the ISDT. Therefore, if the ISDT elements are not filled completely, that means the rest of the Roadmap is still not complete and vice versa. In missing case, some components or their elements including ISDT are missing and need refinements.

Fischer and Gregor (2011), Piirainen and Briggs (2011), Alturki et al. (2011) are only, up to date, works that suggest engaging of Design Theory, ISDT4 as instantiation of Design Theory, with DSR methodology. They assert that the inclusion of Design Theory with DSR methodology increases transparency and rigor of the DSR. Piirainen and Briggs, “argue that the DT [Design Theory] will improve transparency and rigor of DSR research” (Piirainen & Briggs, 2011, p. 50). However, the Roadmap proposed in Alturki et al. (2011) is the only IS DSR that implements the notion of complementing Design Theory with DSR methodology.

C. In response to the call from Fischer and Gregor (2011) to specify DSR steps that feed the ISDT elements, we develop links between the Roadmap Activities and the elements of the ISDT. Initially we focus on one component in the Roadmap, component A- DSR Activities and Cycles.

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4 ISDT gives a comprehensive perspective on DSR outputs (Alturki, et al., 2011).
which consists of many steps (see Figure 3), and specify which steps feed each element of the ISDT. Table 3 shows the association between the Roadmap’s Activities and ISDT elements. The Reader should note that this connection is tentative and needs to be validated more.

<table>
<thead>
<tr>
<th>Steps of the First Component in the Roadmap</th>
<th>Information System Design Theory Elements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Initiation Steps:</strong></td>
<td></td>
</tr>
<tr>
<td>1  Document the Spark of an Idea/Problem</td>
<td>Purpose and scope, constructs, and justificatory knowledge</td>
</tr>
<tr>
<td>2  Investigate and Evaluate the Importance of the Problem/Model</td>
<td></td>
</tr>
<tr>
<td>4  Define Research Scope</td>
<td></td>
</tr>
<tr>
<td><strong>Build Steps:</strong></td>
<td></td>
</tr>
<tr>
<td>3  Evaluate the New Solution Feasibility</td>
<td>Constructs, principles of form and function, justificatory knowledge, and expository instantiation</td>
</tr>
<tr>
<td>4  Define Research Scope</td>
<td></td>
</tr>
<tr>
<td>8  Define Requirements</td>
<td></td>
</tr>
<tr>
<td>9  Define Alternative Solutions</td>
<td></td>
</tr>
<tr>
<td>10 Explore Knowledge Base for Support for Alternatives</td>
<td></td>
</tr>
<tr>
<td>11 Prepare for Design and/or Evaluation.</td>
<td></td>
</tr>
<tr>
<td>12 Develop (Construction)</td>
<td></td>
</tr>
<tr>
<td>13 Evaluate</td>
<td></td>
</tr>
<tr>
<td>14 “Artificial” Evaluation</td>
<td>Testable propositions by specifying how the design fulfils requirements and achieves planned goals.</td>
</tr>
<tr>
<td>15 “Naturalistic” Evaluation.</td>
<td></td>
</tr>
<tr>
<td><strong>Test Steps:</strong></td>
<td></td>
</tr>
<tr>
<td>13 Evaluate</td>
<td></td>
</tr>
<tr>
<td>14 “Artificial” Evaluation</td>
<td></td>
</tr>
<tr>
<td>15 “Naturalistic” Evaluation.</td>
<td></td>
</tr>
<tr>
<td><strong>Reflection steps:</strong></td>
<td></td>
</tr>
<tr>
<td>14 “Artificial” Evaluation</td>
<td></td>
</tr>
<tr>
<td>15 “Naturalistic” Evaluation.</td>
<td>ISDT, if appropriate, is finalized, including principles of implementation and artefact mutability.</td>
</tr>
<tr>
<td>16 Communicate Findings</td>
<td></td>
</tr>
</tbody>
</table>

**Table 3**  The association between the Roadmap’s steps and ISDT

Though Table 3 implies that components of ISDT are addressed incrementally and cumulatively across the DSR Roadmap Activities, it is acknowledged that often the artifact gets built and then reflection allows abstraction and theorizing. The specification of the theory would occur in step 14; before then there could be iterative development of ideas, but the theory would be in prototype form, or non-existent. In section 2.2.3, it is mentioned that ISDT is incrementally populated from the content of the CDR or at one time when the DSR is complete.

D. Building associations between the Roadmap and ISDT mentioned in previous lesson entails thinking of Roadmap’s scenarios. Three scenarios have been identified: (1) building evaluated abstract design, (2) building evaluated abstract design with instantiation, and (3) building instantiation based on evaluated abstract design. The underlying principle of this typology is that the ISDT has compulsory and optional elements which are populated by DSR activities; and not all designs can be instantiated instantly (Gregor & Jones, 2007; March & Smith, 1995). Thus, some steps in the Roadmap are not required for some types of research that do not populate optional elements, (7) principles of implementation, and (8) expository instantiation. In other words, not all DSR compulsorily needs to execute all steps in the Roadmap. However, in cases where researchers are targeting all ISDT elements, then they have to go through all steps; see
Table 4 below. Consequently, we alter the Roadmap to have two entrance gates and two exist gates. The reader should notice that all scenarios are under Design Research\(^5\) type.

<table>
<thead>
<tr>
<th>Roadmap’s scenarios</th>
<th>Information System Design Theory (ISDT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building evaluated abstract design</td>
<td>Elements [1-6]</td>
</tr>
<tr>
<td>Building evaluated abstract design with instantiation</td>
<td>Elements [1-8]</td>
</tr>
<tr>
<td>Building instantiation based in evaluated abstract design</td>
<td>Elements [7-8]</td>
</tr>
</tbody>
</table>

**Table 4** The mapping between the Roadmap themes, ISDT elements and Roadmap’s steps.

E. Principles underpinning the Roadmap might be required to be explicitly developed. These principles will prove that the Roadmap is built rigorously. Initially many principles are suggested, but they need more investigation. Here we mention three as an example of Roadmap’s principles:

- **Instant and Systematic Knowledge Coding**: the Roadmap has a novel component so-called Central Design Repository (CDR) that documents recognized knowledge during DSR progression. This means every single step can be read or written in the CDR.

- **Researcher/Designer-Centric effort**: the Roadmap is for DSR which depends on creativity (Hevner & Chatterjee, 2010) of researchers/designers’ to discover problems, seen or unseen needs, or innovation. Researchers in DSR are the main stakeholders and play the key role; this is the key difference between DSR and Action research (Alturki, et al., 2012).

- **Design-Instantiation Separation**: as we see that there are compulsory and optional elements of ISDT, the Roadmap separates steps that feed them. Thus, there are three themes that should be considered when planning for DSR.

- **Stages and Cycles**: Roadmap’s activities will be structured in into various stages; each stage has many steps. There will be two kinds of cycles; the first DSR Progress Cycle which means the DSR completes all steps in one stage and moves forward to another stage. The second cycle is DSR Refinement Cycle which means the DSR researchers find deficiency or missing information and decide to go back to correct it or add it to a previous stage.

There are many other principles which require close attention and further details, before the final Roadmap can be derived. For instance, consideration must be placed on how the roadmap derives (or can derive) theorized and generalized artifacts, and the Roadmap’s ability to trace DSR attempts (success or fail) etc.

### 6 CONCLUSION

Design Science Research (DSR) has emerged as an important approach in Information Systems (IS) research. However, a holistic approach for the conduct of DSR in IS is yet to be confirmed. While there are many methodological guidelines for DSR available, there is debate on their completeness and validity. Alturki et al (2011) present a DSR Roadmap claiming to address this gap. In this paper, we examine the Alturki et al (2011) Roadmap, mapping it against the Idealized Model for Theory Development (IM4TD) presented by Fischer and Gregor (2011).

In this analysis, the Roadmap is viewed through two different perspectives. The first perspective is on the Roadmap’s construction. The second perspective is on the Roadmap’s outputs; artifacts resulting from following the Roadmap as a DSR methodology. The analysis illustrates that the two contexts of discovery and justification, and the three forms of reasoning as presented in the IM4TD, are considered from both perspectives in the Roadmap design. We conclude from this comparison that the Roadmap considers and resolves some issues raised by the authors of the IM4TD. This Analysis gives an indication that the rigor, and completeness of the Roadmap, from a theory development and

\(^5\)We assume the reader knows the differentiation between Design Science and Design Research and he is aware that these two are under Design Science Research DSR; for more details see Alturki et al. (2012).
reasoning perspective holds strong, thus giving the Roadmap a firmer base. The analysis also points to some refinements that can be done to the Roadmap (which have already been addressed in Section 5 of the paper).

This paper also contributes with insights on the application of the IM4TD. By applying it to the validation of the Roadmap, it shows how one can use IM4TD deductively in the validation of a methodology, and how IM4TD can improve DSR methodologies.

While this preliminary evaluation of the Roadmap through the IM4TD lens has been revealing, in the spirit of the original Roadmap, further attention to its rigor, usefulness, clarity and completeness, taking into careful consideration learnings reported herein is warranted. Such further conceptual scrutiny will be followed by empirical testing of the Roadmap involving its application across a range of DSR circumstances. Expert workshop to evaluate the first perspective of the Roadmap, and focus group and interviews to evaluate the second perspective of the Roadmap are also planned as future tasks of this study.
Reference


Järvinen, P. (2007). Action research is similar to design science. *Quality and Quantity, 41*(1), 37-54.


