Markus Helfert
Brian Donnellan (Eds.)

Communications in Computer and Information Science 388

Design Science: Perspectives from Europe

European Design Science Symposium, EDSS 2012
Leixlip, Ireland, December 2012
Revised Selected Papers

Springer

Communications in Computer and Information Science 388

Editorial Board

Simone Diniz Junqueira Barbosa
Pontifical Catholic University of Rio de Janeiro (PUC-Rio), Rio de Janeiro, Brazil

Phoebe Chen
La Trobe University, Melbourne, Australia

Alfredo Cuzzocrea
ICAR-CNR and University of Calabria, Italy

Xiaoyong Du
Renmin University of China, Beijing, China

Joaquim Filipe
Polytechnic Institute of Setúbal, Portugal

Orhun Kara
TÜBİTAK BİLGEM and Middle East Technical University, Turkey

Igor Kotenko
St. Petersburg Institute for Informatics and Automation of the Russian Academy of Sciences, Russia

Krishna M. Sivalingam
Indian Institute of Technology Madras, India

Dominik Ślęzak
University of Warsaw and Infobright, Poland

Takashi Washio
Osaka University, Japan

Xiaokang Yang
Shanghai Jiao Tong University, China

Markus Helfert Brian Donnellan (Eds.)

Design Science: Perspectives from Europe

European Design Science Symposium, EDSS 2012
Leixlip, Ireland, December 6, 2012
Revised Selected Papers

Springer

Volume Editors

Markus Helfert
Dublin City University, School of Computing, Ireland
E-mail: markus.helfert@computing.dcu.ie

Brian Donnellan
National University of Ireland, Maynooth
Innovation Value Institute, School of Business, Ireland
E-mail: brian.donnellan@nuim.ie

ISSN 1865-0929 e-ISSN 1865-0937
ISBN 978-3-319-04089-9 e-ISBN 978-3-319-04090-5
DOI 10.1007/978-3-319-04090-5
Springer Cham Heidelberg New York Dordrecht London

Library of Congress Control Number: 2013955618

CR Subject Classification (1998): K.6, H.4, H.5, J.6, D.2, H.1, I.2, K.4

© Springer International Publishing Switzerland 2013
This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed. Exempted from this legal reservation are brief excerpts in connection with reviews or scholarly analysis or material supplied specifically for the purpose of being entered and executed on a computer system, for exclusive use by the purchaser of the work. Duplication of this publication or parts thereof is permitted only under the provisions of the Copyright Law of the Publisher's location, in ist current version, and permission for use must always be obtained from Springer. Permissions for use may be obtained through RightsLink at the Copyright Clearance Center. Violations are liable to prosecution under the respective Copyright Law.
The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.
While the advice and information in this book are believed to be true and accurate at the date of publication, neither the authors nor the editors nor the publisher can accept any legal responsibility for any errors or omissions that may be made. The publisher makes no warranty, express or implied, with respect to the material contained herein.

Typesetting: Camera-ready by author, data conversion by Scientific Publishing Services, Chennai, India

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

Preface

This book contains papers presented at the European Design Science Symposium 2012, held in conjunction with the Intel European Research and Innovation Conference Series (ERIC) 2012.

The purpose of the symposium is to bring together researchers and practitioners interested in practical aspects of design science. Design science creates and evaluates IT artifacts intended to solve identified organizational problems. Such artifacts are represented in a structured form that may vary from software, formal logic, and rigorous mathematics to informal natural language descriptions. Design science research (DSR) has become an accepted approach for research in the information systems (IS) discipline with a dramatic growth in recent, related literature. In particular, DSR holds promise as a paradigm that can establish the relevance of academic information systems research for IS practice. The rich phenomena that emerge from the interaction of people, organizations, and technology need to be qualitatively assessed to yield an understanding of the phenomena adequate for theory development or problem solving.

In his editorial titled "Design Science, Grand Challenges, and Societal Impacts," Hsinchun Chen claims that "although explanation-based research has a long history and important role in the MIS community, it is my belief that much of the future high-visibility, high-impact IT research opportunities are surrounding the 'design and implementation of innovative business solutions,' the essence of 'design science' MIS research." In Europe, we find a particularly vibrant and active design science research community and we provide an annual forum – The European Design Science Symposium (EDSS) – for that community to publish their research and exchange opinions that contribute toward the further development of this important MIS research stream.

In ESSS 2012 we had three keynote presentations from leading thinkers in design science, which were complemented by three paper tracks.

In the first keynote presentation, Joan van Aken focused on the development of design science for social system design through rigorous research. He pointed out that this type of design science research faces a fundamental methodological problem, not present in design science research for (purely) technical systems: human agency. The particular challenges that he explored were: (1) how to deal with human agency in DSR for social systems, (2) the basic research strategy for rigorous DSR for social systems, (3) the typical research product of DSR, (4) the design proposition, and (5) the use of these research products through research-informed practice.

In the second keynote presentation, Alan Hevner proposed a complementary evaluation model for DSR drawn from evolutionary economics. An innovative fitness-utility model was presented that captures the evolutionary nature of design improvements and the essential DSR nature of searching for a satisfactory design across a design fitness landscape. A key premise of this new thinking is that the evolutionary fitness of a design artifact is more valuable than its immediate usefulness. The presentation concluded with a discussion of the strengths and challenges of the fitness-utility model for performing rigorous and relevant DSR.

In the third keynote presentation, Krsto Pandza concluded rather skeptically that design science may not offer such a distinct perspective on management as a field of study. His skepticism is based on the design science scholars' rather arbitrary use of Simon's intellectual legacy, particularly the superficial differentiation between explanatory-based and prescriptive-based social sciences, and the promises such a comparison hold for prescriptive outcomes in management. His paper contributed to the design science debate in management by identifying three different types of design, each based on different ways artifacts emerge. These identified differences have profound consequences for understanding design science as an explicitly organized and systematic approach to design. He concluded that later conceptualizations of design science do have a place, but offer only a particular perspective – one that is relevant for a narrow set of organizational phenomena. Finally, he argued that the design analogy is an important one in the current debate about the nature of management studies if it highlights the creation of novelty and disruption of stability. It also offers a way of thinking about the exposition of uncertainty, in contrast to highlighting rules and principles that offer a prescriptive promise to guide the design of social artifacts.

In the first track, Frank Devitt and Peter Robbins explored the relationship, commonalities, and complementarities between design thinking and design science in the context of an introduction to the broader discipline of design and its history, the desire of management scholars to be relevant to practice, and the nature of that practice. They find that design thinking and design science are complementary components of an overall design paradigm, the appropriate application of either approach depending on the context and nature of the problem being addressed. Göran Goldkuhl used a paradigmatic foundation in pragmatism to identify three main subpractices of design research: theorize, build, and evaluate. He also identified three external practices/communities: the research community, general practice, and local use practice. The different practices are related to each other through the construct of an activity cycle. Seven different activity cycles are specified in the paper: theorize–build cycle, theorize–evaluate cycle, build–evaluate cycle, theorize–research community cycle, design research–general practice cycle, build–use cycle, and evaluate–use cycle. Jonas Sjostrom and Madelen Hermelin presented Babbler – a novel concept for community translation. A proof-of-concept (software implementation) that was built and put into use in an information systems development project. Following a design science research approach, the concept and the software were evaluated through log analysis and interviews with translators. The authors demonstrated various qualities of the concept and its implementation, including its effectiveness, efficiency, reliability, workflow, implementability, and performance. Lessons learned, implications for future research, and implications for practice were discussed.

In the second track, Arkın Efeoğlu, Charles Møller, and Michel Sérié described a solution prototype that is composed of blending product and service prototype that has particular impacts on the dualism of DSR's "build" and "evaluate." They used Van de Ven's research framework because it offers potential for agility and iteration. A correlation between Hevner's and Van de Ven's framework was analyzed. Jim Kenneally, Martin Curley, Ben Wilson, and Michael Porter's paper detailed how 16 acute-care hospitals from across Europe and North America were able to plan a more holistic approach to the strategy, implementation, and running of electronic medical record (EMR) and general IT services. The paper outlined a design science approach within the information systems (IS) field to developing and applying here-tofore separately utilized IS management artifacts; namely, the IT Capability Maturity Framework (from IVI) and EMR Adoption Model (from HIMSS Analytics). The combined benefits of this approach allow acute-care hospitals to more holistically plan IT capability enhancements toward achieving improved eHealth outcomes. Jack Anderson, Alan Hevner, and Brian Donnellan proposed a new innovation model that leverages DSR concepts and principles. They outlined the six stages of "DRIVES" with brief descriptions of the activities performed during the stages.

In the third track, Łukasz Ostrowski, Plamen Petkov, and Markus Helfert examined various perspectives of data quality in a flexible service-oriented environment. They presented a process that would assess data within service-oriented environments based on business rules. The process was developed following design science principles, and they underlined the literature review perspective. Philip Huysmans and Jan Verelst showed how normalized systems provide a practical way of developing information systems, adhering to a sound theoretical basis, through the so-called pattern expansion of software elements. They describe a research project to design an analysis method geared toward the development of normalized systems software systems using a the design science methodology. While empirical methods are often integrated in design science projects, there are currently no clear guidelines on how both research methods can and should be combined in a rigorous way. They explore a mixed-methods research approach to provide a sound methodological approach for their research project. Brian O'Flaherty, Simon Woodworth, Colm Thornton, and Yvonne O'Connor's paper addressed the challenge that although cloud computing applications and services go hand in hand, there is no clear mechanism for ensuring that the cloud applications are designed from the customer's perspective. The paper shared early insights of an exploratory study seeking to define a cloud service design theory leveraging service blueprinting as a means to ensure customer-centric design. The development of the proposed design theory addressed both the artifact (in this case a predictive analytics cloud service) as well as the process itself (the derivation and application of an evolved service blueprint accounting for aspects specific to cloud services).

The European Design Science Symposium is organized in conjunction with the Innovation Value Institute, Ireland (www.ivi.ie), the Business Informatics Group at Dublin City University (http://big.computing.dcu.ie/) and in association with the Irish Chapter of the Association for Information Systems (IAIS).

We wish to extend our appreciation to our distinguished speakers and contributors. We hope you will find the papers in this book interesting and valuable and we hope they represent a helpful reference in the future for all those who need to address challenges related to the design science mentioned above.

September 2013

Markus Helfert
Brian Donnellan

Organization

General Chairs

Martin Curley	Intel/Innovation Value Institute
Alan Hevner	University of South Florida

Program Chairs

Markus Helfert	Dublin City University
Brian Donnellan	National University of Ireland Maynooth/ Innovation Value Institute

Industry Chair

Jim Kenneally	Intel

Local Organizing Chair

David Fleming	Intel

Program Committee

Par Agerfalk	Uppsala University, Sweden
Auinger Andreas	University of Applied Sciences, Upper Austria, Austria
Stephan Aier	University of St. Gallen, Switzerland
Liam Bannon	University of Limerick, Ireland
Sven Carlsson	Lund University, Sweden
Gabriel Costelloe	Galway-Mayo Institute of Technology, Ireland
Martin Curley	Intel/Innovation Value Institute, Ireland
Edward Curry	DERI - National University of Ireland, Galway
Frank Devitt	National University of Ireland Maynooth, Ireland
Brian Donnellan	National University of Ireland Maynooth, Ireland
Owen Foley	Galway-Mayo Institute of Technology, Ireland

Markus Helfert	Dublin City University, Ireland
Alan Hevner	University of South Florida, USA
Anne Huff	National University of Ireland Maynooth, Ireland
Dimitris Karigiannis	University of Vienna, Austria
Jim Kenneally	Intel/Innovation Value Institute, Ireland
Thoa Pham	Dublin Institute of Technology, Ireland
Michael Rosemann	Queensland University of Technology, Australia
Jonas Sjostrom	Uppsala University, Sweden
Jan Verelst	University of Antwerp, Belgium

Table of Contents

Invited Papers

Research Papers

Design Science: Valid Knowledge for Socio-technical System Design

Joan E. van Aken

Eindhoven University of Technology
J.E.v.Aken@tue.nl

Abstract. Information systems are socio-technical systems, i.e. complex arrangements of hardware, software, procedures, data and people. The literature provides ample design science to support the design of the technical components but much less so for the social ones. Main stream social science does not produce much design science as research in these disciplines is dominated by the paradigm of the explanatory sciences for which physics is the role model. In these disciplines there is as yet very little research on the basis of the paradigm of design sciences like medicine and engineering. The reasons for this include a fundamental methodological problem, which emerges if one wants to develop design science for the social world and which is not present in engineering and largely absent in medicine. It's cause is human agency. However, this problem can be solved. This article will show how one can develop design science, i.e. valid knowledge produced by rigorous research to support designing, for the social world. The nature of the aforementioned methodological problem will be discussed, followed by a presentation of a research strategy by which one can overcome this problem. This strategy, objective and systematic social experimental learning, will be discussed and will be illustrated by some examples from the field of organization and management. Finally some suggestions are given on the development of design science for the social components of information systems.

1 Introduction

Information systems are socio-technical systems, i.e. complex arrangements of hardware, software, procedures, data and people (March and smith, 1995). The overall performance of an information system strongly depends on the quality of both its technical and the social components and on the quality of their interactions.

The literature provides ample valid generic design knowledge (knowledge that may be called design science) to support the designing of the technical components of information systems. However, for designing the social ones there is much less design science available (Hevner, March, Park and Ram, 2004). One may get the impression from this that it is not quite possible to develop design science for the social world. The thesis of this article is that it *is* possible to develop design science for the social world by rigorous research, be it that the nature of design knowledge for the social world differs from that for the material world as are the strategies to develop design

M. Helfert and B. Donnellan (Eds.): EDSS 2012, CCIS 388, pp. 1–13, 2013.
© Springer International Publishing Switzerland 2013

science for these two worlds. The reasons for this include a fundamental methodological problem associated with the development of design science for the social world, a problem which is not present in developing design science for the material world. This problem is caused by human agency.

In this article I will discuss the nature of this methodological problem and I will present a research strategy that can be used to overcome this problem. This strategy, objective and systematic social experiential learning, is in itself not new. It is essentially a series of case studies, often in Action Research mode. The contribution of formulating this strategy is in the first place the articulation of the reasons for using this strategy in developing design science for the social world, thus enabling researchers to optimize (and justifying) their research designs.

In the next section I will discuss the nature of design science and in the subsequent one the nature of design science research and in particular the role of research paradigms in developing research strategies, including research strategies aiming at producing design science. This discussion will be illustrated by a few examples from my own field, organization and management. Section 4 will focus on research strategies for developing design science for the social world, starting with a discussion of the aforementioned methodological problem in doing so. Finally section 5 will give the conclusion.

2 Design Science

'Science' can be defined as an academic discipline and as a body of knowledge (scientia being the Latin word for knowledge), i.e. valid knowledge produced by rigorous academic research. Design science as a body of knowledge can loosely be defined as a body of valid knowledge *on* designing: descriptive and explanatory knowledge of design processes as these can be found in the world. It can also be defined as knowledge *for* designing, knowledge designers can use to make their designs[1].

This distinction is often presented as one between descriptive and prescriptive (or normative) knowledge, but I don't like the terms 'prescriptive' or 'normative', as they seem to originate from the old quest for the one best way of organizing. Of course, if you have found this one best way of organizing you'll want to prescribe its use. However, the one best way of organizing is a mirage as effective ways of organizing are strongly context dependent, and even for a given context there are always several ways of effective organizing (for instance, a sound way of organizing can misfire in the hands of an incompetent manager, while a questionable approach may be successful in the hands of a competent or lucky manager). The contribution of academic research is not (and cannot) be to produce prescriptions to be followed unquestionably by practitioners, but rather to propose to the practitioner, dealing with a certain field problem, one or more possible generic interventions or solutions,

---

[1] See e.g. Cross (1995), who makes a distinction between research *into* design, producing understanding of the design process, and research *for* design, producing instructions on how to design.

together with their indications and contra-indications and the evidence supporting this. This generic knowledge can then be used by the practitioner to *design* his/her specific intervention or solution for his/her specific field problem.

In this article I will use both meanings of design science, starting with the second one. Design science, then, can be defined as a body of *valid generic knowledge on how and what to design, produced by rigorous research.* Design science thus can refer both to methodological issues, the 'how', and to substantive issues, the 'what'. 'Validity' is used in this definition as a container concept, referring to the various characteristics of valid knowledge, like internal and external validity, reliability and controllability.

Finally, with 'rigorous research' I do not mean something like 'following *universal* principles and rules for high quality research', but research following sound procedures and rules *pertinent to the nature of the research question and the nature of the research object*. So, rigorous research to determine, say, the speed of light, follows different procedures and rules than, say, research to determine the causes of the first World War or to develop design science to support the design of expert systems. The research strategy to develop design science for the social world presented below, objective and systematic social experiential learning, does not look like research in physics (by many considered as the mother of *all* (sic) sciences). I intend to show that it is well suited for the above mentioned research question (develop design science) and research object (social systems).

3 Design Science Research

Design science research is research, aiming to produce valid knowledge *for* designing. Research paradigm issues play a crucial role in developing research strategies. By 'research paradigm' I mean the combination of research questions asked, the research methodologies allowed to answer them, the nature of acceptable evidence and the nature of the pursued research products[2].

In IS-research two dichotomies are important: the explanatory versus the design science research paradigm, discussed by March and Smith (1995) and within the design paradigm the paradigm for developing design science for the technical components of information systems versus the one for developing design science for their social components (Hevner et al., 1995). I will elaborate below the dichotomy of explanation versus design (based on Van Aken, 2004 and 2005) and in section 4 the one of technical versus social.

3.1 The Explanatory Research Paradigm

The role model for explanatory research is physics and with it all natural sciences. But main stream research in most social sciences is also based on the explanatory paradigm.

---

[2] In this I follow Lakatos' thesis that academic research can be regarded as being informally organized in 'research programs', their members sharing a given research paradigm and through this defining characteristic using research strategies which are different from those of other research programs (Lakatos, 1991)

The mission of explanatory research is to develop understanding of the world that is. Research is driven by pure knowledge problems, like the question of how sunlight and rain produce a rainbow. Knowledge on pure knowledge problems is developed as an end in itself. The validity of this knowledge is justified on the basis of its explanatory validity.

In this quest for truth, like true statements on the causes of a rainbow, the researcher uses an observer perspective: the objective, disinterested observer. Students in these research programs or disciplines are trained by researchers to become researchers. The iconic research product is the, if possible quantitative, causal model in which some phenomenon is explained in terms of some independent variables. For explanatory research Newton's laws of motion, with their elegant and simple quantitative formulations and their enormous explanatory power, are the example to follow.

3.2 The Design Science Research Paradigm

The role models for design science research are engineering and medicine. Design science research is interested in the world that can be, a better world. The mission of design science research is to develop knowledge, which can be used to improve the human condition by changing the world that is. Design science is knowledge as a means. The validity of design science research outcomes is justified on the basis of pragmatic validity: does the application of this knowledge (in the intended context) indeed produce the desired outcome(s).

Research, of course, aims to develop knowledge, but design science research is not driven by pure knowledge problems, but by field problems. A field problem can be defined as a situation in reality, which according to (some or all) stakeholders can or should be improved, like the fuel efficiency of engines, the speed of microprocessors, the condition of cancer or heart patients, and traffic congestions. The researcher uses an actor perspective, the perspective of one or more actors or groups of actors that are in a position to use one or more interventions to solve the field problem (like engineers, medical doctors, entrepreneurs or politicians). Students in these research programs or disciplines are (primarily) trained to become professionals, able to use their knowledge to solve field problems. They are trained by professionals or ex-professionals, who, therefore, understand the nature of professional work. An academic discipline for which design science research is main stream research can be called a design science (using the first meaning of the term design science). Engineering, medicine and IS-research can be regarded as design sciences.

Design science research aims to produce knowledge to be used to change – intending to improve – reality. Compared to 'disinterested' explanatory research this involves many more ethical and political issues: is the intervention or system to be designed, further developed and field tested ethically desirable or acceptable and which parties can be expected to profit from the used of the new intervention or system and for which parties may their interests be harmed. For much design science research these issues are fairly trivial, for other design science research they can be very significant. The law, of course, may set clear constraints, but in many cases the stakeholders in the research in question have to decide among themselves on how to address these issues.

Design science research can produce various kinds of research products, but the iconic one is the design proposition[3], articulating for a given type of problem-in-context a solution concept, together with the outcome(s) to be expected on application of this solution concept. For the understanding of the nature of design science research, the understanding of its key research product is essential. Therefore in the next sections this iconic research product is discussed, in subsection 3.3 at an abstract level, in subsection 3.4 by a number of illustrations.

Table 1 gives a summary of the differences between explanatory and design science research.

Table 1. The differences between explanatory and design science research (based on Van Aken, 2004)

Explanatory research (as in e.g. in physics)	Design science research (as e.g. in medicine and engineering)
– driven by pure knowledge problems; observer perspective – mission: to understand, a quest for truth (knowledge as an end) – interested in the world that is – justification on the basis of explanatory validity – students are trained to become researchers by researchers – iconic research product: the causal model	– driven by field problems, actor perspective – mission: to improve the human condition (knowledge as a means) – interested in the world that can be – justification on the basis of pragmatic validity – students are trained to become professionals largely by (ex) professionals – iconic research product: generic solution and the design proposition

3.3 The Design Proposition

As said, design science research is driven by field problems. More precisely, a design science research project is driven by a *type of* field problem. Its key research product is a generic *solution concept*, i.e. a generic intervention or system that can be used in addressing the type of field problem in question. The solution concept is put into

[3] In Van Aken (2004 and 2005) I use the term ‘technological rule’, drawing on Bunge’s philosophy of technology (Bunge, 1999). For purely rhetorical reasons I now prefer the term ‘design proposition’: technological rule is too ‘technical’ for many in the social sciences and ‘proposition’ is closer to what I want to convey than ‘rule’, with its suggestion of being a stringent instruction.

context by a *design proposition*, the solution concept constitutes the core of the design proposition.

A design proposition follows the basic pragmatic theorem: if you want to achieve Y in situation Z, then perform action X. The core of the pragmatic theorem is the action X; in the design proposition this is the above mentioned solution concept.

The most informative design proposition is the grounded and field tested one. ‘Field testing’ means that the solution concept has been tested in its intended application domain. Design science is generic knowledge, but typically not universal knowledge. Rather it is mid-range theory, only valid in a specific application domain. Field testing is to provide the evidence for the pragmatic validity of the design proposition.

‘Grounding’ means that the rule also gives an explanation on why this solution concept gives in this context the desired outcome.

Design propositions can be formulated using the so-called CIMO-logic (Denyer, Transfield and van Aken, 2008). This format is based on the above-mentioned pragmatic logic and uses a combination of C (problem-in-context), I (intervention), M (mechanisms) and O (Outcome): for this problem-in-***C***ontext it is useful to use this ***I***ntervention, which will produce through these ***M***echanisms this ***O***utcome.

It is important to note that de CIMO-logic is just what it says, a type of logic. Actual design propositions need not to be formulated as one-liners. The size of given proposition can range from indeed a one-liner to an article, a report or a whole book. But in any case one should find a discussion of the type field problem and its typical context, the intervention (like an action, a series or arrangement of actions, the implementation of a type of management or information system, etc.), the mechanisms producing the outcome and the outcome itself (possibly having both desired and non-desired elements). Further information to be given can (and often should) include the evidence for its pragmatic validity (preferably including the results from field testing) and possibly some user instructions, including the indications and contra-indications for the use of the presented solution concept.

3.4 Examples of Design Propositions

In this section I will give five examples of design propositions. The first two very simple ones in order to get an impression of the logic of design propositions, the next three based on PhD-theses in the field of organization and management from Eindhoven University of Technology (which all can be downloaded from its website www.tue.nl).

One: The context of the first one is a prison, the field problem being the need to prevent the inmates from escaping (C). The arrangement of interventions consists of using locked doors, windows with bars and guards (I), the mechanisms are the physical constraining of the movements of the inmates, and possibly some deterrence by the guards (M) and the desired outcome is no escapes (O).

Two: The context of the second one is a car park, the field problem thefts from parked cars (C). The intervention the introduction of CCTV (I), the mechanisms deterrence of criminals, allocation of personnel to suspicious situations and less careless behaviour of parkers (M). The desired outcome less theft (O).

Note

- that the first and third mechanism only function if the CCTV-system is well advertised. Knowledge of the mechanisms to be triggered by the intervention often is essential to design a specific intervention for a specific context
- that the solution concept of introducing CCTV looks at first sight a quite effective intervention to reduce theft in a car park, but that actual field testing of this solution concept is needed to optimize this intervention and to get insight its indications and contra-indications
- that the ambition of the developed intervention is not to solve the field problem in its totality, but only to produce a significant contribution to its solution.

Three: This example is taken from Opdenakker (2012).The field problem is the desire to improve the performance of virtual teams in the field of product and process innovation (C). A virtual team is a geographically distributed teams, so a team with very limited face-to-face contacts between team manager and team members. The developed solution concept was a face-to-face kick-off meeting at the start of the project (I). This intervention was not expected to solve the whole field problem, but was intended to produce a significant contribution. The desired outcome (O) was an effective team, rather than good project performance as there usually are several more factors (including team external factors) impacting team performance than team management. Opdenakker found that the primary mechanisms (M) were empowerment (team members must be able to operate largely unsupervised, so need to be able to use much discretion in their actions), collective insight in the team task and collective commitment to make the project a success. Knowledge of these mechanisms is essential to design a good kick-off meeting: in order that the desired outcome is to be realized the kick-off meeting must be much more than a ritual; it must be designed in such a way that these mechanisms are triggered.

Four: This example is taken from Menzel (2008) and shows the variety of possible solution concepts. The field problem is desire to improve the innovativeness and entrepreneurship of well-established industrial companies. One strategy to do so is the promotion of intrapreneuring, stimulating staff at various levels to come with initiatives for new business outside present lines of business. This involves a dilemma: on the one hand new business is welcomed, while on the other business outside present businesses clashes with many established procedures and interests. Menzel developed and tested a role-play, based on a case in which intrepreneuring was introduced in a company, to be used by companies wanting to do the same. By playing this role-play the participants, both managers and professionals, can get a first-hand experience of both the potential and the pitfalls of entrepreneuring, including the above-mentioned dilemma. After the role-play serious discussions could be had to detail the introduction of this new approach (new to the company).

In CIMO-terms the field problem was the desire to improve the innovativeness of an industrial company (C), the intervention (I) was having this role-play played, the *direct* outcome of this intervention (O) an increasing awareness of the various aspects of intrapreneuring, an intrapreneuring favourable culture and a collective commitment to make it a success. The mechanism (M) to produce these outcomes was experiential learning (a mechanism difficult to trigger by other means, short of actually doing it).

Note that, as in example two, the intervention does not solve the field problem in its totality. This is often the case in design science research. The desired outcome may, like the improved innovativeness of the company in this example, be subjected to many influences, several outside the scope of possible interventions. Therefore it is difficult, if not impossible, to rigorously prove the impact of a given intervention on this ‘bottom line variable’ (unless, of course, one has a sufficiently large number of cases to do valid statistical analyses). In such cases the approach is to develop an intervention which produces a *direct outcome*, for which the intervention-outcome relation can be proven and for which there is a plausible argument that this direct outcome will have a significant impact on the desired *ultimate outcome* (like innovativeness in this example), without having the scientific obligation to determine *how much* this impact will be.

Five: Finally, the last example refers to the involvement of end users in product innovation (Weber, 2010 and 2011). On the basis of a number of own cases, combined with extensive research synthesis, Weber developed 28 design propositions on how to involve end users in product innovation, both in the industrial and the services sector. A few propositions dealt with the overall strategy of involving end users and the other ones gave propositions with respect to deal with specific issues, like how to find interested end users, how to motivate them and how to feed the ideas received in an effective way into the company’s innovation process.

3.5 The Swamp of Practice

A design proposition with its embedded solution concept is *generic* knowledge. On application to solve a *specific* field problem (belonging to the type of field problem for which the solution concept in question has been developed) these have to be contextualized (so redesigned) by the practitioner. This requires in depth knowledge of the specific context and, furthermore, professional competence and creativity. Solution concepts are not developed for the layperson but for professionals.

In his insightful book *The Reflective Practitioner* (on professional work in the social world like organization design and change or psychotherapy) Donald Schön (1983) has made a distinction between the high ground of theory and the swamp of practice. Design propositions and solution concepts are the result of analysis and design on the high ground. On this high ground the researcher cannot and should not take into account all the details, interferences and turbulence of working in the swamp. The ambition of design science research in the social world is not to dampen the swamp but to provide here and there some solid ground from which to proceed.

4 Design Science Research in the Social World

4.1 The Fundamental Methodological Problem for Design Science Research in the Social World

Actions to create a world that can be cannot be logically *derived* from specifications or other inputs. They have to be *designed* and designing involves abduction, a creative jump – large or small – from the various inputs to the design process to something new.

Designing is done in synthesis-evaluation iterations. The synthesis step involves the above-mentioned creative jump to a design, a possible solution of the design problem at hand, after which the evaluation step establishes whether or not the synthesized design satisfies the specifications for that design. Apart from the competence and creativity of the designer(s), the quality of the synthesis strongly depends on the quality of the inputs to the design process, like problem analysis, context analysis, design specifications and generic knowledge on the design issue at hand. However, one cannot justify a design on the basis of these inputs like one can logically justify the validity of an answer to an explanatory question on the world that is by describing the way one has found this answer. For designs the justification is not from question via research design to answer, but the other way around: from design (the answer to the design question) via evaluation or (field) testing, showing that the design meets the specifications (the articulation of the design question)[4].

The quality of a design depends on the quality of the designers and on the quality of the inputs to the design process, but the rigour of the design science research process is determined by the quality of the evaluation, establishing the pragmatic validity of the design. The basic scientific claim of a design proposition is that its application will indeed produce in the given context the desired outcome. So the core issue in the evaluation of design propositions is the prediction of outcomes of interventions (or the performance of new systems). The royal road to this is field testing, testing of an instantiation of the design in its intended field of application.

In the material world this prediction through field testing does not pose specific methodological problems, different from methodological issues in developing valid explanations. The reason for this is that in the material world there are *invariant, universal, individual behaviour determining mechanisms*. An electron does not have the freedom to act tomorrow differently from today, nor in New York differently from Amsterdam. A machine, developed, assembled and tested in Helsinki, will work next month likewise in Dublin. Through these mechanisms in the material world the test results on one instantiation of a given research product (for which standard analytical methodologies of explanatory research can be used) can be readily generalized to other times and places.

This applies to engineers and to some lesser extent also to medical doctors[5]. However, in the social world there are no universal, invariant, individual behaviour determining mechanisms. Therefore, the prediction of outcomes of interventions in the social world is difficult. In the social world the evaluation of one application of a design proposition in the social world cannot simply be generalized to other times and places. This is the fundamental methodological problem of design science research in the social world. It is caused by human agency.

---

[4] See van Aken, Berends and van der Bij (2012) for a further discussion of the design process.

[5] This ‘lesser extent’ is due to the fact that in testing interventions medical doctors deal with living material of which there are never exact copies in other times and places, so they need RCT’s or other sophisticated research designs to generalize test results.

4.2 Research as Experiential Social Learning

Even if there are no behaviour determining mechanisms in the social world there are regularities and patterns in social behaviour. In fact, the prediction (within certain ranges) of the behaviour of other people in response to one's own behaviour is an almost universal human competence. Without this competence intentional social behaviour would be impossible. The extent to which this competence is universal can be seen in people, lacking this competence because of an autistic disorder.

This competence is developed by personal social experiential learning, learning from personal experiences[6]. It is subsequently applied through case-based reasoning: the present setting is compared – typically unconsciously – with similar prior experiences and a line of action is chosen on the basis of the outcomes of the actions in these previous experiences. This makes that this mode of personal learning is limited by the scope of one's personal experiences: outside this scope the competence of predicting human behaviour is much less, as can be seen when acting in a very different culture than one's own.

Personal experiential social learning was the basis of teaching in business schools at the time they were still more or less trade schools: most teachers were experienced managers 'telling the boys how I did it', implying that their students just had to imitate their behaviour to be successful. However, experiential learning can also be done at an academic level: *objective and systematic experiential social learning.* Through this research strategy one can learn what the outcomes of certain types of interventions in various social settings can be.

Research as experiential learning is learning on the basis of series of case-studies with detailed descriptions and analyses of problem, context, interventions and outcomes, giving deep insight in these elements and in their interrelations. 'Thick' descriptions, as opposed to the strongly reductionistic models of quantitative research, are needed to make the case-studies into real social experiences. So the strategy involves series of rigorous case-studies on a certain type of field problem, using a certain type of intervention of system to address this field problem. These case-studies can be executed in 'Action Research mode', in which case the researcher is involved in developing and testing the intervention, but the researcher can also take a more observer role, observing how others develop and use interventions to address the field problem.

The research is to be made 'objective' by using the various methods of rigorous case-studies, like controlled observations, triangulation, 'thick' descriptions, careful cross-case analyses and member checks and by alfa- and beta-testing of the developed interventions or systems.

Experiential learning through series of case-studies involves working alternating in the *practice stream* and in the *knowledge stream* (Andriessen, 2007). In the practice stream one operates in the swamp of practice on a specific example of the type of field problem one wants to address, interacting with the various local stakeholders as they are solving their specific problem. In the knowledge stream one operates on the high ground of generic theory to generalize the findings of the various individual

[6] See e.g. Kolb (1984) on the power of experiential learning.

case-studies through careful cross-case analyses. Interacting with other researchers and with practitioners interested in developing generic theory one tries to establish what is case-specific on the one hand and what can be learnt from these cases for use in other settings on the other.

Like in personal experiential learning the application of what has been learnt is done through case-based reasoning. The outcomes of interventions are predicted on the basis of a qualitative comparison with interventions in similar settings, somewhat like judges using case-law in determining verdicts[7].

4.3 Discussion

Research on the basis of series of case-studies certainly is not a new one, nor if these are carried out in Action Research mode in which the researcher actively is involved in designing and implementing interventions (see e.g. Sein et al., 2011). The intended contribution of the argument presented here is the articulation of the reasons for using this strategy for design science research in the social world and an articulation of the rigour in design science research for the social world, thus providing researchers a starting point for making their own research designs and for justifying them for the academic forum.

This research strategy of objective and systematic experiential social learning is to be used in cases where the impact of the social behaviour on the outcomes of interventions is significant. If this is not the case, other means for data capture and analysis may be better suited. For instance, if one is developing an inventory control system for which users still are expected to use much discretion in placing their orders, one instantiation of the system cannot readily be generalized to other times and places. In this case a learning strategy may be appropriate. If, however, its users can be expected to follow its order suggestions closely, one can make a quantitative model of the inventory system and analyse its behaviour by calculus or simulation.

One may also want to use quantitative methods if the intervention-outcome is non-complex, e.g. when both intervention and outcome can be described by one or a very limited number of variables instead of by complex social ‘Gestalts’. This can, for instance, be the case if one is interested in the impact of a price decrease on sales.

But the choice of a learning strategy instead of other ones, including quantitative ones, ultimately depends on whether one has a large N or a small n research question: a leaning strategy is especially appropriate if one has a small n question. Large N questions tend to lead to quantitative research designs (and often data capture through surveys), resulting in a ‘science of the average’; small n questions need answers of a ‘science of the particular’. Large N answers may turn on application into small n questions. For instance, if large N research has resulted in a decision that a significant

[7] Case-based reasoning, that is making judgements through qualitative comparisons of a given case with prior cases, is also used in engineering design for evaluating designs of a complexity that makes more formal evaluation impossible (see e.g. Leake, 1996, and Watson, 1997).

price decrease is desirable, this may turn into a small n question on how to do it in a given market with specific customers, competitors and regulators.

Professional work in the social world typically needs science-of-the-particular answers, but may be informed on general tendencies by science-of-the-average answers. Researchers, only using an observer perspective, tend to limit their interests to science-of-the-average questions (which often may be answered by quantitative causal models). An actor perspective typically leads to science-of-the-particular questions, which may rather be answered via a learning approach.

5 Conclusion

To date the design science available to support the design of the social components of information systems is too limited (Hevner et al., 2004). In this article I have shown that it is possible to develop such design science through rigorous research and I have discussed how to do this through a learning strategy. As long as the social sciences do not produce much design science for their field IS-researchers will have to do it themselves with respect to the social components of their information systems.

With respect to the technical components one instantiation is a valid research product as in the material world one instantiation can be generalized (within a certain range) to other times and places. This is possible because in this world there are invariant, universal and individual behaviour determining mechanisms. Human agency makes that such mechanisms are not present in the social world. Because of this one instantiation of an information system produces with respect to its social components rather anecdotal evidence. But by using a rigorous learning strategy, more specifically objective and systematic experiential social learning, one can develop valid design science for the social components of information systems, possibly in the form of field-tested and grounded design propositions.

References

1. Andriessen, D.: Designing and testing an OD-intervention, Reporting Intellectual Capital to Develop Organizations. Journal of Applied Behavioral Science 43(1), 89–107 (2007)
2. Bunge, M.: Scientific Research II: The Search for Truth. Springer, Berlin (1967)
3. Cross, N.: ‘Editorial’. Design Studies 16, 2–3 (1995)
4. Hevner, A.R., March, S.T., Park, J., Ram, S.: Design Science in Information Systems Research. MIS Quarterly 28(1), 75–105 (2004)
5. Kolb, D.A.: Experiential learning: Experience as the source of learning and development. Prentice-Hall, Englewood Cliffs (1984)
6. Lakatos, A.: Falsification and the Methodology of Scientific Research Programmes. In: Lakatos, I., Musgrave, A. (eds.) Criticism and the Growth of Knowledge. Cambridge University Press, Cambridge (1991)
7. Leake, D.B.: Case-Based Reasoning: Experiences, Lessons and Future Directions. American Association for Artificial Intelligence, Menlo Park (1966)
8. March, S.T., Smith, G.F.: Design and natural science research in information technology. Decision Support Systems 15, 251–266 (1995)

9. Menzel, H.C.: Intrapreneurship-conductive Culture in Industrial R&D. Doctoral Thesis Eindhoven University of Technology (2008)
10. Opdenakker, R.J.G.: Strategic Momentum in Virtual R&D Teams. Doctoral Thesis Eindhoven University of Technology (2012)
11. Sein, M.K., Henfridsson, O., Purao, S., Lindgren, R.: Action Design Research. MIS Qarterly 35(2), 1–19 (2011)
12. Van Aken, J.E.: Management Research on the Basis of the Design Paradigm: the Quest for Field-tested and Grounded Technological Rules. Journal of Management Studies 41(2), 219–246 (2004)
13. Van Aken, J.E.: Management Research as a Design Science: articulating the research products of mode 2 knowledge production. British Journal of Management 16, 19–36 (2005)
14. Van Aken, J.E., Berends, J.J., Van der Bij, J.D.: Problem Solving in Organizations: A Methodological Handbook for Business Students, 2nd edn. Cambridge University Press, Cambridge (2012)
15. Watson, I.: Applying Case-Based Reasoning: Techniques for Enterprise Systems. Morgan Kaufman Publishers, San Francisco (1997)
16. Weber, M.E.A., Weggeman, M.C.D.P., Van Aken, J.E.: Developing what customers really need: involving customers in innovation. International Journal of Innovation and Technology Management 9(3), 1250018.1-15 (2010)
17. Weber, M.E.A.: Customer Co-creation in Innovations. Doctoral Thesis Eindhoven University of Technology (2011)

Beyond Usefulness: A Fitness-Utility Model for DSR

Extended Abstract Based on EDSS 2012 Keynote

Alan R. Hevner

Information Systems and Decision Sciences, College of Business,
University of South Florida, Tampa, FL 33620
ahevner@usf.edu

1 The Dependent Variable in Design Science Research

Current thinking in design science research (DSR) defines *utility* as the primary research goal (e.g. [1, p. 80]). In this context, the close relationship of utility to practical *usefulness* is emphasized. With a goal to increase the impacts of DSR, the search for the dependent variable in DSR requires some rethinking. A pair of alternative dependent variables can be considered: *design fitness* and *design utility*. In the case of fitness, we focus on its biological meaning—the ability of an entity to reproduce itself and evolve from generation to generation. In the case of utility, rather than viewing it as being roughly equivalent to usefulness, we focus on its meaning in fields such as economics and decision sciences, where it serves as the basis for ranking decision alternatives. Naturally, usefulness plays an important role in determining both fitness and utility. Neither of these variables, however, is solely determined by usefulness. Indeed, we believe that understanding the relationship between the three variables via a new fitness-utility model complements current thinking and provides important insights into the nature of design science.

2 Fitness and Utility

How best to understand and evaluate the artifact in DSR is explored. Two concepts from other disciplines for this task are fitness (biology) and utility (economics).

Fitness
To understand fitness, it is useful to begin by proposing two alternative definitions of the fitness of an organism:

Fitness Definition #1: The fitness of an organism describes its ability to survive at a high level of capacity over time.
Fitness Definition #2: The fitness of an organism describes its ability to replicate and evolve over successive generations.

Which definition of fitness you prefer likely depends on your perspective. If the individual in mind were our personal physician, we would strongly prefer he or she focus on definition #1. Terms such as physical fitness, mental fitness and emotional

M. Helfert and B. Donnellan (Eds.): EDSS 2012, CCIS 388, pp. 14–19, 2013.
© Springer International Publishing Switzerland 2013

fitness all correspond to this general class of definition. If, however, the individual were an evolutionary biologist, definition #2 would be overwhelmingly preferred. An organism lacking the capacity to reproduce and evolve rapidly goes extinct. Thus, we will refer to the second definition of fitness when we use the unqualified term.

Utility
Similar to fitness, the term utility is used in a number of ways. When we consider the utility of a tool, we are normally referring to its usefulness. As currently used in the context of DSR, that is the prevailing meaning. Hevner, et al. [1, p. 83] state: “The utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods.” This implies utility to be a characteristic of the design and its intended application context. Economists, on the other hand, employ the term utility in a different way. Specifically, they posit each individual to have a utility function that can be used to rank choices in the context of decision-making. The assumption that individuals seek to maximize utility is, in fact, foundational to the field of economics. When we employ the term utility in the rest of the paper we assume its economic meaning and further assume that it represents a complex function that is not adequately described by the single usefulness dimension.

3 Relationship of Fitness, Utility, and Usefulness in Design Science

The concepts of fitness and utility can readily be applied to the design of systems. Design artifacts perform two key roles in the design search process:

1. They provide evidence that a particular design candidate is feasible, has value, can be effectively represented, and can be built. This serves to help us better understand the shape of the design fitness landscape, moving combinations from the unknown to the known category.
2. Through careful evaluation, they provide a basis for choosing between alternative designs.

The first of these directly impacts our knowledge of design fitness. The second refines our estimate-of-fitness that is a basis for choice; it therefore involves changing our utility function through learning.

Where design systems differ from biological evolution is in the role played by intentionality. In the design space designers intentionally concentrate on areas of the design fitness landscape where promising candidates have been identified. What that means is that while utility serves as an estimate-of-fitness for design artifacts, it also feeds back into the fitness landscape itself since a low fitness evaluation for a particular design candidate will discourage further investigations into nearby regions of the design landscape. This, in turn, reduces the fitness of those regions since placing less effort into building artifacts based on a particular design will necessarily reduce the flow of future artifacts based on that design (which is how we define fitness). Moreover, the shape of the utility function is likely to be guided by two forces: the nature of the evaluation artifacts being studied *and* by actual experience from artifacts developed for use. Thus, the experience of artifacts placed in practice has the ability to impact the design fitness landscape just as evaluation artifacts do. Thus the new fitness-utility model can re-frame DSR as follows:

The goal of DSR is to impact the design space so as to ensure a continuous flow of high fitness design artifacts. This impact is accomplished in two ways: through the production of artifacts that demonstrate the feasibility of new designs and through improving the utility function that we use to assess the fitness of evaluation artifacts.

4 DSR Evaluation under the Fitness-Utility Model

The most interesting and extensive changes resulting from the new Fitness-Utility would be in our understanding and application of the evaluation of the design artifact. The evaluation would be based on a more extensive and detailed utility function that estimates the fitness of the artifact.

The fitness-utility model recognizes a large number of characteristics (i.e., design attributes) that could potentially impact design fitness. These are illustrated in Figure 1. As the intersecting ellipses suggest, we continue to expect "usefulness" to play a major role in design fitness. The area within the fitness ellipse outside of the intersection with the usefulness ellipse reflects other characteristics that can impact fitness that are not a direct consequence of usefulness (although they may be correlated with it). The specific characteristics listed in Figure 1 are intended to serve

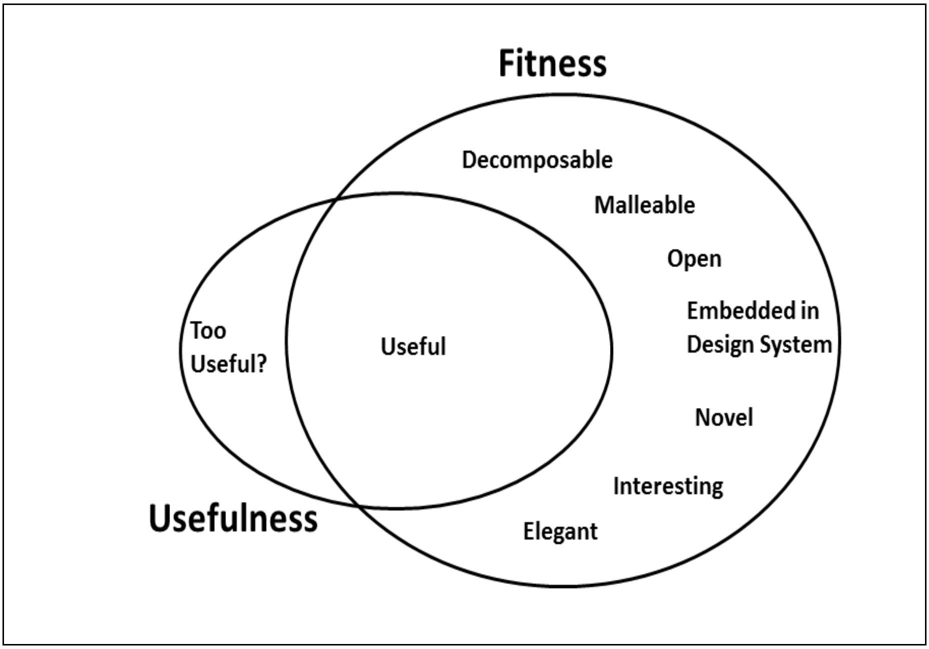


Fig. 1. Design Candidate Fitness Characteristics and Usefulness

as a preliminary list. These characteristics serve one or more purposes that help to support sustainable growth of designs over time:

1. They support the design's ability to evolve incrementally;
2. They encourage experimentation by users and other designers; and
3. They are effective *memes* meaning that they contain ideas of a form that propagate and replicate.

Each of the listed characteristics in Figure 1 is briefly discussed here, again emphasizing that this list is exploratory, and not intended to be complete. For each characteristic a brief argument is made as to why it should be included in a design artifact's utility function. A fuller discussion is found in [2].

Too Useful? – It can be very expensive to transition from one design to a very different design. Over the long term, however, the highly useful proprietary design that cannot easily adapt to the changing landscape represents an evolutionary dead end. As such, it is not be considered a high-fitness design. In fact, the tendency of organizations to stick with designs that have proven useful is a well-documented phenomenon known as the Innovator's Dilemma [3].

Decomposibility - The seminal work that launched the study of design science is Herbert Simon's *The Sciences of the Artificial* [4]. The second half of the book is largely devoted to explaining why systems tend to evolve from nearly decomposable subsystems. Indeed, even under the existing DSR goals, decomposability is likely to exert a strong influence on design quality and would therefore be evaluated as part of the design. In addition, such systems tend to be easier to construct, since work on individual components can be conducted separately.

Malleability - Often enhanced by decomposability, the malleability of an artifact represents the degree to which it can be adapted by its users and respond to changing use/market environments [5]. User-malleability can be divided into levels, such as customization, integration and extension. Here customization refers to the ability of a design to be tailored to a user's preferences. Integration involves the ability to conveniently share the capabilities of one artifact with another, creating a resultant artifact with capabilities beyond those of either original design. The ability to create mash-ups of web components on a single page is an example of this capability. Extension means adding new capabilities to an artifact.

Openness - Another design characteristic that has the potential to impact design fitness is the degree to which artifacts are open to inspection, modification, and reuse. Open designs—particularly when combined with decomposability and malleability—encourage further design evolution by making it easier both to see how an artifact is constructed and to modify existing components of the artifact.

Embeddedness in a Design System - We would expect design artifacts that are the product of a sustainable design system environment to evolve more rapidly than artifacts that are produced in a context where design is an unusual activity. A design system can also manifest itself as a community of users and designers, providing contributors with intrinsic motivation to contribute.

Novelty - A design may be considered novel if it originates from an entirely new region of the design space. Once such a design candidate has proven viable, other design candidates from the same region are likely to follow in an attempt to locate the local peak on the fitness landscape. A genuine new invention is a difficult goal for DSR research projects and we can expect few research contributions to be true inventions. [6] However, exploration for new ideas and artifacts should be encouraged regardless of the hurdles.

Interestingness - Normally, a design artifact is created in order to explore or demonstrate some specific purpose. From time-to-time, however, an artifact may demonstrate unexpected emergent behaviors that are worthy of subsequent investigation and the creation of subsequent artifacts. An artifact may also be constructed in an unexpected way that intrigues other designers or design researchers. We characterize such designs as *interesting*. Broadly speaking, the benefit of an interesting design is its propensity to diffuse.

Elegance - In many areas of design, such as architecture, consumer products and apparel, there is an ongoing tension described as form versus function. Function relates to practical usefulness. Form, in contrast, describes aesthetic elements such as appearance that do not necessarily serve a useful purpose, yet nevertheless increase the user’s utility. The characteristic of an IS design artifact that corresponds to form might best be referred to as *elegance*. Like quality, elegance is hard to define in a rigorous manner and yet characteristics that might be associated with it—such as compactness, simplicity, transparency of use, transparency of behavior, clarity of representation—can all lead to designs that invite surprise, delight, imitation, and enhancement. Equally important, they can cause a design artifact whose usefulness has yet to be demonstrated to endure.

5 Conclusions

The fitness-utility model for design science research is viewed as a complement to the existing usefulness model, rather than as a competitor. The two models focus on different objectives, are most applicable to different artifacts, tend to examine different units of analysis, are appropriate for different time horizons, are likely to employ different research methods, and will tend to be of greatest interest to different client constituencies. An understanding of the factors contributing to usefulness is central to the fitness-utility model. Many factors outside of usefulness may contribute to fitness, but we expect usefulness will typically prove to be an important factor in most design settings. Nevertheless, we believe the fitness-utility model for DSR is too important to ignore. It is our goal to alert researchers and reviewers of these differences and offer some justification as to why they are necessary. In doing so, it is our hope to stimulate future DSR thinking along the lines of the fitness-utility model.

References

1. Hevner, A., March, S., Park, J., Ram, S.: Design Science in Information Systems Research. MIS Quarterly 28(1), 75–106 (2004)
2. Gill, T.G., Hevner, A.R.: A Fitness-Utility Model for Design Science Research. In: Jain, H., Sinha, A.P., Vitharana, P. (eds.) DESRIST 2011. LNCS, vol. 6629, pp. 237–252. Springer, Heidelberg (2011)
3. Christensen, C.: The Innovator's Dilemma. Harper Collins, New York (1997)
4. Simon, H.: The Sciences of the Artificial, 3rd edn. MIT Press, Cambridge (1996)
5. Gregor, S., Jones, D.: The Anatomy of a Design Theory. Journal of the AIS 8(5), Article 2, 312–335 (2007)
6. Gregor, S., Hevner, A.: Positioning and Presenting Design Science Research for Maximum Impact. MIS Quarterly 37(2) (2013)

Strategy Formulation as a Design Science: An Investigation into the Effects of Deterministic and Path-Creation Design on the Formulation of a Strategy

Gerard Duff and Krsto Pandza

Leeds University Business School, Maurice Keyworth Building, University of Leeds, Leeds LS2 9JT, UK
{bngd,kp}@lubs.leeds.ac.uk

Abstract. In this study we examine the sharp distinctions made in Pandza and Thorpes [1] BJM paper between deterministic and path creation modes of design science activity. This investigation will be presented through a single case study that examined the process of strategy formulation for 'innovation' in the operating company of a multinational organisation that embodied both social and technical activity. The context of strategy and strategy formulation is an apt sphere to investigate this subject space as strategy attempts to determine the future of objectives of the firm through both social and technical activity. In building upon Pandza and Thorpe's proposition, it is argued here that through the process of strategy formulation as a design science, actors traverse between the two modes of design activity to achieve an outcome. We will highlight that this process has a higher degree of inter-relational complexity than previously envisioned.

Keywords: Design Science Theory, Deterministic design, Path-creation, Strategy formulation, case study.

1 Introduction

Many academics have attempted to theories the design process in order to explain and understand the various aspects of design practice. Since the 1960's, many facets of design and designing have been investigated such as: the management of the design practices, the configuring of a design problem, the nature of design activity, the philosophy of the design and design methods [2]. Despite these investigations, as of yet, a comprehensive and agreed upon description has yet to be developed [3]. Similarly, there is no right or singular approach to design that can be universally applied across industry and occupation. Recent research conducted by Eckert et al, [4] suggests that with regards to the development of a technical artefact, design practices across various industries are broadly similar in nature, with variance occurring in relation to emphasis on particular activities. Eckert et al, [4] also suggest that variances in design process can be fewer across industries when compared to those within the same industry. However, descriptions such as this are made at a high level and often serve little use in the practical application of design as they do not provide any detail of the process of design. Lawson (via Wyn and Clarkson 2005[5])

M. Helfert and B. Donnellan (Eds.): EDSS 2012, CCIS 388, pp. 20–28, 2013.
© Springer International Publishing Switzerland 2013

describes such research as follows *'… about as much help in navigating a designer through his task as a diagram showing how to walk would be to a one year old… knowing that design consists of analysis, synthesis and evaluation will no more enable you to design than knowing the movements of breaststroke will prevent you from sinking in a swimming pool'.*

Since the strategy formulation process came to the fore in the mid 1980's a number of case studies e.g.[6,7] have highlighted that strategy formulation process rarely conforms to the idealistic linear model, i.e. input through to output. These case studies have shown that the strategy process itself is an evolving progression with many twists and turns where the final outcome may not resemble what was initially envisaged. Rumelt [8] suggests this could be as a result the 'ill-structured' nature of the strategy process itself, where vague, uni-dimensional policies lead to complex problem solving activities with no predefined method for clarification. Contemporary business models emphasize speed and agility with the ability to think broadly and opportunistically at all levels [9]. Detailed long-range plans focused on achieving the 'correct' answer [10] are no longer seen as the key to success [11]. Traditional econometric-led approaches to strategy formulation, i.e. the analysis of both the internal and external environment in a highly artificial way via use of snap-shot techniques are regarded as ill-equipped to keep at pace with the modern business setting [9]. This is due to the presentation of data to the strategist within a codified knowledge in a number of formats.

Liedtka and Mintzberg [12], suggest that the 'design' approach moves beyond the sterility of traditional methods and inserts speed and flexibility; viewing the world as fluid and evolving. Having the ability to develop strategy in the modern business environment needs a change of focus and mind-set; moving away from incremental percentage growth setting and towards creating the ability to shape and respond in a continuous and interactive way. To achieve this, the business outcome approach taken to strategy formulation has to be conducted in a similar vein. Like the approaches taken by for example, designers and architects; approaching strategy should be seen as a stepping-stone process that continually evolves as each goal is achieved [13] while maintaining a perspective on larger overarching goals. As the process matures, new dynamics occur thus forcing the strategy itself to evolve. This evolution should be seen as par de course and not as an issue. The focus of achieving the 'correct' answer with a specific focus has its merits and has achieved many results. This however, assumes that the world in which the strategy is being developed for, is constant and ever-changing. Conversely, numerous examples exist proving this is not the case. Strategy as design assumes that the world is ever changing and that each 'answer' is a stepping-stone to the next. Designing often necessitates a wide perspective to an issue often including a variety of perspectives and foci, e.g. aesthetics, functionality, economic and socio-political dimensions of both the design artefact and, the design process itself.

2 Theory Background

Academic interest in the area of management as design is in its infancy. In 'The science of the Artificial', Simon [14] calls for management to further its knowledge about design and design process as a method towards understanding and solving managerial issues. In ‘Managing as Designing’, Boland and Collopy [10] draw several parallels between both management and design with consideration given to striking a balance between having a decision attitude and a design attitude. However as Dunne and Martin [13] note, ‘the idea of applying design approaches to management is new and, as yet, largely undeveloped’. This stipulates that further empirical and theoretical research is required ‘to understand the scope of the concept and its potential’ *ibid.*

When reviewing the works of Simon, Pandza and Thorpe [1] pose a number of interesting questions about the nature by which different artefacts emerge and how prone different types of design are to the acceptance of rules. The first of these is deterministic design, which has synergies with professional engineering, through which all design decisions made by the designer determines the structure, behaviour and performance of the artefact. Each decision is based on pre-existing knowledge in a form that has been codified and prescribed. The second of these is path-dependent design, which is akin to evolutionary design in engineering, whereby artefacts develop gradually as a result of experimental learning or trial and error. This is interesting, as it demonstrates prolonged difficulties that exist with regards to the implementation of heuristics and design rules in technical and social design; as this was the primary focus of the design methods movement which disbanded and referred to as a ‘wicked problem’ [15, 16]. The prescriptive power of this approach lays not so much in the use of design principles informing interventions, as in identifying limitations of decision-making and processes as a result of managing ambiguity due to designer limitations driven by their own biases [17]. Path-creation is the final perspective identified by Pandza and Thorpe. This view is similar to that of radical design in engineering. The application of this approach is best suited to those problems that are fuzzy [18], ill structured, with a high degree of unknowns that are fundamental to the advancement of a concept; In other words, an un-structured approach to building an unknown solution to an ambiguous need. In practice, the agent is the driving force in the search for novelty and in doing so, identifying the processes through which an organisation can secure its current and future position. In this mode, the designer or design team use of their embedded imagination creates uncertainty by design decisions as it opens up issues of traceability and repeatability. Through this mode, things begin ‘fuzzy’ and become clearer as a result of cycles of iteration. The prescriptive power of this approach is the identification of processes that enable amenability of evolutionary mechanism to serve the purpose of design.

3 Methods

Academic interest in strategy formulation has declined since the 1980’s, but its industrial application has not, with 88% of companies surveyed using strategic planning as a means to plot their future needs and requirements [19]. Current thinking in this area is based largely upon superficial depictions of strategy practices founded upon retrospective qualitative interviews and quantitative questionnaire data [20].

This renders the question as to why academic interest or at least output has declined? Could it be due to limited access to organizational strategy formulation practices? Then, the question arises as to why academics are unable to gain access in order to study this phenomenon? Is it a confidentiality or trust issue? The model of engagement is presented here as possible means by which further research of the phenomena could be developed.

3.1 Case Award Partner

Through and EPRSC CASE award, a research alliance was established between Leeds University Business School and BULBz. The scope of this research is based within the context of an operating company of a multinational national conglomerate that is primarily located within the UK utilities sector. BULBz is a tier one company within the utilities market i.e. it is a business-to-business supplier, facilitating the provision of product from business-to-customer. The UK utilities sector can be broadly divided into three different sectors: water, power and gas. BULBz operates across the three utility sector divisions, in which it facilitates the provision of water, power and gas through the constructing and embedding of the equipment required to transport these commodities.

Building on success of a number of technical innovation activities, an innovation hub was formed in 2007. Technical innovation at this point, was on the periphery of the organisations primary strategic focus. Consequently, it did not receive any specific long-term goal aspirations, and therefore it maintained its function on an ad-hoc basis. Technical innovation used an emergent strategy driven by the need of a customer, while receiving little organisational push from outside the division. The strategies utilised by the department were emergent in themselves, thus developing unique paths in the creation of technologies with relative levels of success.

With shifting markets and evolving customer focus, ‘innovation’ became a key driver for the future ambitions of the company as a whole and was seen to be a key mechanism in maintaining the current customer base, in addition to attracting new prospects base. This has led the organisation to attempt to formalise its innovation activity at through a deterministic mode both a macro and micro level. The objective was to enhance the ability to innovate in a predictable way, via the formation of heuristics for technological development and pathways. With each operating division tasked to improve innovative capabilities the first step being the development of a short-term strategic plan for ‘innovation’. Each director subsequently engaged with a senior manager within each division to foster a strategy. This research has engaged one department’s attempts to develop a strategic plan for innovation.

Innovation has been recognised as important facilitator in economic growth [21]. However, much is yet to be understood with regards to the different social mechanisms driving and impeding innovative practices across industries. The utilities sector in particular has been shown to have an innately unique set of characteristics with regards to innovation practices and approach when compared to other UK sectors [22]. BULBz have long since been recognised as a leading technical innovating company within this sector. BULBz however, have recognised the need to improve social mechanisms that facilitate these innovative capabilities.

3.2 Action Research Framework

Research was gathered through a two-stage method. An initial study to understand the key perspectives actors have on innovation and, the fundamental factors influencing their innovation practices on both a macro and micro level. Interviews were conducted throughout the organisational hierarchies and across various operating divisions all of which are connected by a single technical innovation hub. The findings from the initial study were then used to inform and direct a larger research agenda focused on the formulation of a medium term strategy for the innovation agenda of the organisation.

The primary approach taken in observing strategy formulation was action research. The action research approach engages with the organisation and participates in the development of a solution to a specific issue. In the context of this research project, the strategy manager took the role of primary designer, with the academic acting a quasi-team member-come-consultant. This provided the means to directly observe and intervene in the strategy formulation process. This approach has congruence with Scheins [23] model of action research, known as clinical inquiry. The clinical inquiry approach involves the researcher participating in the clients' inquiry process; in this case the client is the driving force [24]. In contrast to a typical research programme with a clinical inquiry framework, the practitioner identifies a need for change and in consultation with an academic partner to investigate an agenda.

It must be noted that the focus on strategy and strategy formulation within an innovation context was not the original focus of this research project, however due to the collaborative nature of this engagement and the serendipitous alignment of agendas, a refocus was agreed upon and executed. The nature of this approach allows for such actions to take place but raises questions about degrees of flexibility in the design process and the relationship between the two parties.

The early and prolonged engagement allowed for a deep understanding of both the historical and current relationships between the three operating organisations. Despite there being little crossover in everyday business activity, within an innovation context, attempts were made to make a cohesive push in a unified direction in a bid to develop novel artefacts as a result of cross pollination of expertise from the varying disciplines. However due to legacy issues presenting themselves as cultural distrust among the various divisions and different modes of working, this vision failed to materialise. At this juncture, each division was independently challenged to develop a short-term strategy for innovation activity.

From this point, the lead author took an active role in the development of a strategy for the water and gas division of the organisation; this was led by the organisation's innovation and strategy champion. As previously noted, this approach consisted of the academic taking a secondary supporting role which facilitated first-person real-time observations to be conducted; accompanied by regular ad-hoc interviews to gauge why certain decisions were being made.

4 Findings and Discussion

In the theoretical paper by Pandza and Thorpe [1], a sharp distinction was made between different forms of design: deterministic and path-creation. They highlighted a number of pre-condition characteristics in the deterministic design science process i.e. finite time horizon, the sequence of the design process and the knowledge available. In this case, these were evident. However, in reality, interesting tensions are apparent where gaps exist if the pre-conditions are not fully met and as will be demonstrated in this case study. To be highlighted over the course of the development of a social artefact, the engagement between the deterministic and the path-creation models are not as clearly defined as previously envisioned. What was observed within this case was an approach that engendered characteristics of both deterministic and path-creation approaches; this was due to the need and desires to create novelty. There were aspirations to create ‘a game changing space’ that would break from the traditional Lean processes approach which was customary in previous strategies, but in creating this novelty, an element of the known existed that at times, necessitated a need to take a path-creation approach. To demonstrate the ebbs and flows between the deterministic and path-creation modes, the strategy formulation process is broken down into a three-phase process, where in this case, the completion of the strategy is seen as its delivery for further deliberation with senior executive; and not implementation of the strategy.

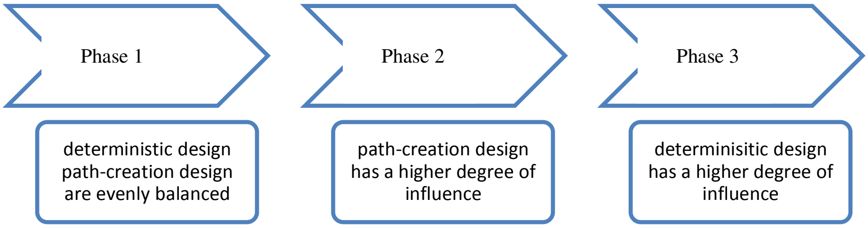


Fig. 1. Phase of strategy formulation

Phase 1:

The brief received by the lead designer at this point, was to develop a short-term strategic plan inclusive of the following: focusing the advancement of technical artefacts, outlining what technical artefacts currently existed, and which areas these could be exploited in. The lead designer however, deemed this to be an opportunity to break away from legacy issues that were seen to impede the organisation’s ability to innovate, and to develop a high degree of novelty in order to achieve a dramatic breakthrough. This search for novelty failed to preserve stability. There was a keen desire for change. Although at this point, it was unknown what form this would take. From the experience of previous failed strategies, caution was raised in terms of finding a synergy between the old and the new, so as not to alienate the recipients of the strategy with overzealous changes to the current regime. As a result, seen to be a means of progression; the original focus (technical) coupled the development of possible futures (seen as radically different), with emphasis on management structure and cultural change. At this point, a balance became apparent between the desires for both degrees of pragmatism and novelty, with a desire for the strategy to be accepted and implemented coupled with a want for real change that will ultimately bring success through innovation activity to the organisation.

From the outset of the strategy formulation, what we consider to be deterministic and path-creation were both evenly influential in the process. With clear milestones in place (i.e. time horizon, an agenda to create a platform for improvement, a degree of codified knowledge and existing set of tools to formulate the strategy) a strong case can be made for a deterministic design analogy used to describe this scenario. However the desire to create novelty may have considerable social implications and said unknown element elevates the importance of individual agency and the embedded imagination of the designer to moulding the outcome.

Phase 2:

Due to the unknown nature of and the search for novelty, phase 2 the path-creation approach had a higher degree of influence. The approach took an emergent form with interviews being taken to understand the various perspectives of key stakeholders existing both within and outside of the organisation. This resulted in a complex and at times, contradictory set of codified knowledge. The aforementioned contradictions ranged from the complete disbandment of any innovation activity and a refocus on core principles, to the incorporation of innovation as a primary agenda that would have influence on all future activities. However, all interviews acknowledged a need for change from the current model as the effect of Lean methods used to improve organisational output and increase profits has been in decline. On one hand, these interviews were conducted to gain insight in terms of the needs and wants of those affected by any change, while on the other; it created a degree legitimization for any decisions made. Unlike in engineering; when developing a social artefact, verification and acceptance is required through social currency. The early engagement and involvement of key stakeholders was seen as necessary to increase the plausibility of acceptance for a strategy.

Initial brainstorming techniques were used to develop an idealised model of how innovation would be conducted throughout the organisation. Qualitative methodologies were used to analyse and codify interview transcriptions to build a picture of the various possibilities for different strategies. This knowledge was then supplemented by existing published internal and external documents as well as previous successful and failed strategies. Time was taken to imagine possible scenarios and outcomes of various directives. These ranged from the extreme to the incremental and factored in existing frameworks that incorporated process, culture and technologies. This was deterministic in nature as it allowed the designer the space to articulate and envisage the possible outcomes of each strategy. This artificial design space allows decisions reversible, thus allowing for all possible scenarios to be investigated. Although a high degree of codified knowledge was available, in this instance much of the conceptualisation originated from the instinct, insight and intuition of the lead designer, with the codified knowledge used to justify decisions made after the fact.

Phase 3:

'we need to get something down on paper....that will be accepted....we need a win'

The constant time horizon had a major influence on the formulation on the strategy and its creative elements. In this case the focus on novelty and creativity had reduced and was replaced with a need for acceptance. In this case it could be stipulated that the time horizon had a negative influence on the search for novelty. As a result focus shifted from the want to create change to a need to successfully complete a task. Priority was given to the desires of the key stakeholder, *'I know what KC wants in this strategy, don't worry about it, I know what he likes'*. This was in stark contrast to the objectives early on in the creative phases of the design process.

As can be seen throughout the strategy formulation process, there is a co-existence between the deterministic and path-creation approaches. It has been shown that at times these two activities achieve levels of harmony in the progression of an artefact. However it has been demonstrated that harmonisation is tentative at best and often requires trade-offs to occur to reach an output. It could be speculated that in this case the specified time-horizon played had a negative influence on the designer's ability to infuse the desired novelty into the strategy. However this may not be the case and warrants further investigation into number of possible reasons, i.e. areas the ability to identify novelty in a social artefact, tensions with justifying a social artefact, situational effects as well as the role of the designer as a strategist.

5 Conclusion

The focus of this paper is to investigate the sharp distinctions made between deterministic and path-creation modes of design science activity. Through the use of a single case study in strategy formulation, it has been evinced that in practice there is a higher degree of fluidity through these modes than previously envisaged theoretically. The complexities involved in the design of a social artefact highlighted here paid specific attention to the role of both agency and time horizon on the outcome. This paper has demonstrated that in the initial phase of the formulation process, both deterministic and path-creation modes of design expressed similar levels of influence on the development of the artefact. As the process progressed into the mid-stages of the formulation process, path-creation was seen to have a higher degree of influence on decision making due to the desire for novelty. However, in the latter stages of the formulation process, as the time horizon came to a climax and the need to create tangible outputs grew, the deterministic mode became much more evident.

References

1. Pandza, K., Thorpe, R.: Management as design, but what kind of design? An appraisal of the design science analogy for management. British Journal of Management 21, 171–186 (2010)
2. Cross, N.: Developments in design methodology. John Wiley & Sons (1984)
3. Bahrami, A., Dagli, C.: Models of design processes. In: Parsaei, H., Sullivan, W. (eds.) Concurrent Engineering. Springer US (1993)

4. Eckert, C., Clarkson, P.J., Zanker, W.: Change and customisation in complex engineering domains. Research in Engineering Design 15, 1–21 (2004)
5. Wynn, D., Clarkson, J.: Models of designing. In: Clarkson, J., Eckert, C. (eds.) Design Process Improvement. Springer London (2005)
6. Greenwood, R., Hinings, C.R.: Organizational design types, tracks and the dynamics of strategic change. Organization Studies 9, 293–316 (1988)
7. Sminia, H.: Process research in strategy formation: Theory, methodology and relevance. International Journal of Management Reviews 11, 97–125 (2009)
8. Rumelt, R.P.: Evaluation of strategy: Theory and models. In: Strategic Management: A New View of Business Policy and Planning, pp. 196–212 (1979)
9. Liedtka, J.M., Rosenblum, J.W.: Teaching strategy as design: A report from the field. Journal of Management Education 22, 285–303 (1998)
10. Boland, R.J., Collopy, F.: Design matters for management. Managing as Designing, 3–18 (2004)
11. Mintzberg, H.: The fall and rise of strategic planning. Harvard Business Review 72, 107–114 (1994)
12. Liedtka, J., Mintzberg, H.: Time for design. Design Management Review 17, 10–18 (2006)
13. Dunne, D., Martin, R.: Design Thinking and How It Will Change Management Education: An Interview and Discussion. Academy of Management Learning & Education 5, 512–523 (2006)
14. Simon, H.A.: The sciences of the artificial. MIT Press (1996)
15. Rittel, H.W.: On the planning crisis: Systems analysis of the first and second generations. Institute of Urban and Regional Development (1972)
16. Rittel, H.W., Webber, M.M.: Dilemmas in a general theory of planning. Policy Sciences 4, 155–169 (1973)
17. Tripsas, M., Gavetti, G.: Capabilities, cognition, and inertia: Evidence from digital imaging. Strategic Management Journal 21, 1147–1161 (2000)
18. Mendel, J.M.: Uncertain rule-based fuzzy logic system: introduction and New Directions (2001)
19. Rigby, D., Bilodeau, B.: Bain's global 2007 management tools and trends survey. Strategy & Leadership 35, 9–16 (2007)
20. Grant, R.M.: Strategic planning in a turbulent environment: evidence from the oil majors. Strategic Management Journal 24, 491–517 (2003)
21. Cooper, R.G., Edgett, S.J.: Overcoming the crunch in resources for new product development. Research-Technology Management 46, 48–58 (2003)
22. Hellebrandt, T.: Community innovation survey. In: HMRC (ed.) Virtual Micro Data Laboratory Data Brief (2007)
23. Schein, E.H.: Process consultation, action research and clinical inquiry: are they the same? Journal of Managerial Psychology 10, 14–19 (1995)
24. Venkateswaran, R., Prabhu, G.N.: Taking stock of research methods in strategy-as-practice. The Electronic Journal of Business Research Methods 8, 156–162 (2010)

Design Science and Design Patterns: A Rationale for the Application of Design-Patterns within Design Science Research to Accelerate Knowledge Discovery and Innovation Adoption

Martin Curley, Jim Kenneally, and Colin Ashurst

Intel Corporation / NUI Maynooth
{Martin.G.Curley,Jim.Kenneally}@Intel.com,
Colin.Ashurst@newcastle.ac.uk

Abstract. Fundamental to any profession is a common vocabulary for expressing its concepts, and a language for relating them together. Many disciplines draw from a collective body of knowledge (BoK) of "best practices" and "lessons learned" for solving known problems. This body of knowledge is typically comprised of well-defined solutions for known problems plus emergent solutions for ill-defined problems. As design science research results are codified into a knowledge base, they become "best practices" over time through their routine application, feedback and evolution. This paper presents the case to express Design Science Research (DSR) artifacts in design-pattern format – to accelerate insight generation and application of DSR outputs. As the focus of Innovation shifts to Innovation "Adoption", the use of design patterns to help achieve faster and more widespread innovation adoption is likely to increase significantly.

Keywords: Design Science Research, Innovation Adoption, Design Patterns, Practice, Body of Knowledge, IT Management, IS Management, Knowledge Discovery, Practice Sharing.

1 Design Science Research Introduction

Since professions began to emerge, they have relied on interpreting practices drawn from a collective body of defined knowledge - both in terms of emergent and proven practices. For example, great engineers do not just design their products strictly according to the principles of math and science - they must adapt potential solutions to make optimal trade-offs and compromises between known solutions, principles, and constraints to meet the ever-changing demands of cost, schedule, quality, and customer needs. They have to become domain expert problem-solvers, often engaging a reflective process on the utility of chosen solutions and their outcomes.

Design Science Research (DSR) owes its origins to engineering and the sciences of the artificial [1]. DSR is fundamentally a problem-solving paradigm - seeking novel ideas, practices, technical capabilities, and products through which more effective and

M. Helfert and B. Donnellan (Eds.): EDSS 2012, CCIS 388, pp. 29–37, 2013.
© Springer International Publishing Switzerland 2013

efficient use of information systems can be achieved. It seeks to contribute to the underlying BoK through creating and evaluating artifacts intended to solve organizational problems [2], where artifacts can be in the form of constructs, models, methods or instantiations [3] – see Table 1.

Table 1. Design Research Outputs

Artifact	**Description**
Constructs	The conceptual vocabulary of a domain
Models	A set of propositions or statements expressing relationships between constructs
Methods	A set of steps used to perform a task – ‘how to’ knowledge
Instantiations	The operationalization of constructs, models and methods

Figure 1 illustrates the relationship amongst the DSR artifacts outlined in Table 1. Purao [4] and Rossi & Sein [5] suggest an additional fifth research output, better theories. Better theories can be achieved where DSR contributes to a better understanding of the phenomenon through reflection and abstraction.

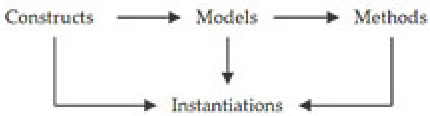


Fig. 1. Relationship among DSR artifacts

2 Opportunity for Design-Patterns

The types of challenges faced in the information systems (IS) field require novel solutions, as requirements are often unstable, possess complex interactions and often call upon cognitive and social skills in developing and communicating solutions [2]. DSR seeks to address these wicked problems [6-7] i.e. to create and evaluate IT artifacts intended to solve organizational problems [2]. The Authors postulate a philosophical alignment between the properties of Design-Patterns and the type of problems being addressed in the field of DSR - Table 2. Design Patterns create a shared language and vocabulary for communicating insight and experience about recurring problems and their solutions [8]. Design pattern properties seek to accelerate learning. They can assist researchers in the field of DSR to more appropriately create, evaluate and communicate the utility of artifacts in given contexts.

Table 2. Philosophical synergies between DSR and Design-Patterns

Design Science seeks to address [6-7]	**Design Patterns' properties** [8]
Unstable requirements and constraints based on ill-defined environmental contexts.	Encapsulation and Abstraction Each pattern encapsulates a well-defined problem/solution and makes clear when they apply. Patterns provide crisp, clear boundaries that help crystallize the problem space and the solution space, and may occur at varying hierarchical levels of conceptual granularity within the domain - representing abstractions of empirical experience and everyday knowledge.
Complex interactions among subcomponents of problem and resulting subcomponents of solution.	Composability Patterns don't just describe modules, but describe hierarchically related structures and mechanisms – they can be composed with other patterns at varying levels of scale. Applying one pattern provides a context for the application of the next pattern, operating like fractals at particular levels of abstraction.
Inherent flexibility to change design processes as well as design artifacts (i.e. malleable processes and artifacts).	Openness and Equilibrium Each pattern is open for extrapolation and improvisation that minimizes conflict among forces and constraints when being applied. In many situations improvement will be achieved by using one pattern or a small number of patterns together, and then making further improvements after review and learning from the results of the initial changes.

Table 2. (*continued*)

Dependence upon human cognitive abilities (e.g., creativity) to produce effective solutions.	Generativity Each pattern has a significant human component, a pattern is the process that generates a solution, but it may generate any one of a vast number of variant solutions (conceivably without repeating the same solution twice). Patterns are intended to help think through how to tackle a situation and should be adapted if necessary as they are applied.
Dependence upon human social abilities (e.g., teamwork) to produce effective solutions.	Generativity Patterns are not designed to be executed without thought, patterns are to be executed by those with judgement, experience, and knowledge – using a combination of individual and collective sense-making.

Understanding of an artifact's utility and its constraints is essential for DSR and the use of design-patterns. Simon [1] proposes the artifact as an interface between an "inner" environment (the artifact itself) and the "outer" environment (the context in which it is used). DSR allows researchers to investigate how artifacts are defined, utilized and impact their context [9]. Furthermore, Benbasat & Zmud distinguish a hierarchal environment of context, structure and task in which the artifact is embedded - Figure 2. Given that DSR identifies situational awareness as one of the key elements to understanding the utility of artifacts, a design 'pattern' format may provide a valuable way to capture and share DSR insights and accelerate innovation adoption. Furthermore, Hevner et al, [2] suggest design research should clearly identify contribution to the archival knowledge base and the communication of the contribution to the stakeholder communities. Design-patterns can also assist professional design in the routine application of the knowledge base to known problems.

Alexander et al [10] envisaged patterns as providing advice about what it was thought best to do to provide a solution and some rationale for why it should be adopted. This advice was set in a problem context showing how the problem usually arose and why it was a problem. Where appropriate, links to other patterns were made, either to acknowledge functional links between sub-problems or to point to necessary prior knowledge. This structure helps sharing of knowledge and provides insight into how, where and when it might be usefully applied.

Value from Innovation is realizable only when Innovations are adopted, therefore facilitating Innovation adoption can accelerate value creation [11]. Integral to the design science research approach are the principles of practice-inspired research and theory ingrained artifacts, and good design patterns should embody both of these for

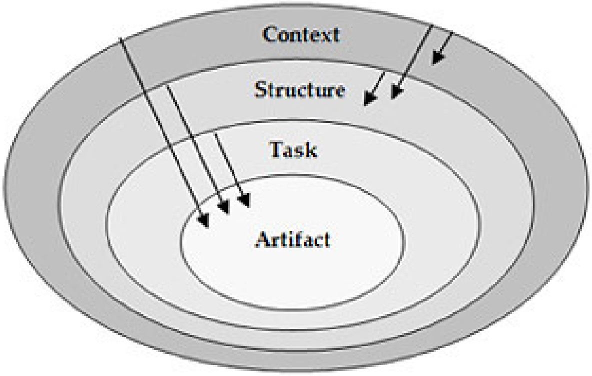


Fig. 2. The IT-Artifact [9]

maximum efficiency and efficacy [12] and ease of adoption. As our world becomes increasingly more complex and challenges even greater, the use of and demand for design patterns to help drive diffusion and adoption of solutions to complex problems will likely increase.

3 Design-Pattern Overview

From an Innovation and IS management perspective, Nandhakumar and Avison [13] highlight the limitations of formal methodologies (cf practices), which often represent only a 'convenient fiction', to provide an appearance of control, but bear little relationship to how work actually gets done: these methodologies often represent a focus on the formal process rather than the actual practices that relate to how people do their work. Some of the unstated assumptions behind transferability of practices across domains include the homogeneity of organizations, transferability, alienability and stickiness and validation [14]. To improve performance it is important to focus how work actually gets done, i.e. on practice, and there is a need for using pattern like concepts to supplement the limitations of formal methodologies as a way of sharing practice.

The definition of a ‘practice’ offered by Wenger et al [15] suggests the following: ‘a set of socially defined ways of doing things in a specific domain: a set of common approaches and shared standards that create a basis for action, problem solving, performance and accountability’. Not only does the concept of a practice appear to be very closely aligned with how people actually work [16], it is also particularly relevant in knowledge-intensive activities, such as IS management [17], where much of the effort is based upon the experiences of individuals and teams. Moreover, the concept of practice relates to the informal organization and how work is actually done by individuals and groups.

Design-patterns help create a shared language for communicating potential solutions and allow users to intelligibly reason about how to use them in various contexts. Patterns were introduced as a design concept by Alexander et al [10] and the Gamma et al, [18,19] book on design-patterns as applied to object oriented programming began to popularize the use of patterns in Computer Science. Patterns have similar philosophies to DSR artifacts i.e. the identification of field-tested technological rules [20] or construction principles, and design rules [21] verified in real-life settings. They represent instrumental and prescriptive knowledge that is typically made explicit in the following form: to achieve outcome Y in a situation X, a design-based action Z might help [20, 22]. DSR artifacts place high emphasis on understanding the utility of an artifact within a given context. Similarly the pattern approach captures and shares how things get done while leaving scope for improvisation and adaptation (for example to reflect different organizational contexts and rationales) – a pattern focuses not so much on an individual practice in a specific organizational setting but rather the form good practice generally takes across different settings and organizations. In essence a pattern is an outline of 'what works' based on observation of practice. Patterns are a way of summarizing and communicating practice within and between organizations.

For our purposes, we have made the following distinction between practices and patterns [23]:

- A practice relates to an approach to getting work done in a specific context. Some authors refer to practices as 'routines.' Practices are what people do within an organization.
- A pattern is an abstraction, a description of a practice. It must lose some of the richness and uniqueness of the related practice but it provides a way to identify and communicate what works.

Patterns represent distilled experience which, through their assimilation, convey expert insight and knowledge to the inexperienced. Once a potential solution has been expressed in pattern form, it may then be more readily applied and reapplied to other contexts, and facilitate widespread reuse and adoption. Patterns provide the core to a solution in such a way that one can use the core solution every time, but implementation should and may vary – so with design patterns we have the core solution and not the exact solution. Therefore, a design-pattern becomes a general reusable solution to a commonly occurring problem within a given context - it is a description or template for how to solve a problem for different situations. It leads to a recommended action or solution. It is a way of sharing advice based on experience of what works in similar situations. By employing design pattern tools we are better equipped to address those limitations outlined earlier.

4 Design-Pattern Format

The format of a pattern, with an explicit focus on the context in which it is useful and explanation of the forces impacting on a situation, makes them particularly suitable for many areas in management of IS and innovation, which are complex and require judgment based on experience. The pattern helps to make explicit and communicate important elements of what would otherwise remain tacit.

Thompson and Walsham [24] showed that if knowledge is to remain useful once made explicit, a link with the context in which the knowledge was used and so in which it might be reused must be retained. The tension between codifying nothing, thereby risking the loss of important information, and trying to codify everything, risking banality, is at the very core of patterns. A pattern is a way to capture and communicate 'what works', how to get things done. A pattern has a simple structure to help capture what is important in a particular activity. It also explicitly provides a link with the context in which the pattern is relevant and provides guidance on usage. The following elements in Table 3 are typically represented in describing a pattern [25], which is typically as short as 1-2 pages.

Table 3. Pattern Template

Name:	the name seeks to capture the essence of the pattern
Summary:	the summary supports the name and reinforces the understanding of the pattern, often with an illustration
Challenge:	a statement of the problem which describes its intent: the goals and objectives it wants to reach within the given context
Context/Rationale:	explains the different forces involved in the problematic situation and how the solution responds to these forces.
Solution:	often equivalent to giving instructions which describe how to construct the necessary work products to show how the problem is solved
Resulting Context:	the state after the pattern has been applied, including the consequences (both good and bad) of applying the pattern. It describes the post conditions and side-effects of the pattern
Links	to related patterns

One of the objectives for using design patterns in DSR should be to assist DSR researchers more effectively explore the frontiers of what's possible and contribute towards a more accessible body of knowledge (BoK) for IS management to solve recurring problems. For example, an iterative Design-Pattern approach was applied in the development of the IT Capability Maturity Framework (IT-CMF) [26, 27] – with the objective for IS management to improve value and innovation from information technology across an array of business contexts. IT-CMF consists of a set integrated design-patterns manifested as artifacts [26, 27, 28, 29]. This format proved successful in accelerating the creation, evaluation, dissemination and application of IT-CMF artifacts. A standard taxonomy enabled the consistent development of linked design patterns, each attempting to map to the pattern template described in Table 3. The application of Design-Patterns within DSR continues to be expanded as part of the on-going development and expansion of IT-CMF. Today, IT-CMF BoK adoption has penetrated many FORTUNE 250 firms, government agencies and small-to-medium businesses – accelerating IT maturity and value from innovation, as well as facilitating on-going research and contributions to the BoK evolution.

5 Conclusion

In summary, the format provided by a pattern can provide a powerful way to capture and share knowledge in complex, knowledge intensive environments where it may be impossible to make key aspects of knowledge fully explicit. This is significant as practices, knowledge or innovations are valuable only when they are applied or used i.e. adopted. This paper presents the case for use of design-patterns within the field of IS design science research. Further research and discussion is required on the proposed merits, possible limitations and use of design-pattern formats, including merits and likely utility to expanding the use of design patterns beyond the field of IS design science research

References

1. Simon, H.: The Sciences of Artificial, 3rd edn. MIT Press, Cambridge (1996)
2. Hevner, A.R., March, S.T., Park, J., Ram, S.: Design Science in Information Systems Research. MIS Quarterly 28(1), 75–105 (2004)
3. March, S.T., Smith, G.F.: Design and natural science research on information technology. Decision Support Systems 15, 251–266 (1995)
4. Purao, S.: Design Research in the Technology of Information Systems: Truth or Dare. GSU Department of CIS Working Paper, Atlanta (2002)
5. Rossi, M., Sein, M.: Design Research Workshop: A Proactive Research Approach. Presentation delivered at IRIS 26, August 9-12 (2003)
6. Rittel, H., Webber, M.: Planning problems are wicked problems. In: Cross, N. (ed.) Developments in Design Methodology, pp. 135–144. John Wiley & Sons, New York (1984)
7. Brooks Jr., F.: No silver bullet: essence and accidents of software engineering. IEEE Computer 20(4), 10–19 (1987)
8. Lea, D.: Christopher Alexander: an introduction for object-oriented designers. SIGSOFT Softw. Eng. Notes 19(1), 39–46 (1994)
9. Benbasat, I., Zmud, R.W.: The Identity Crisis Within the IS Discipline: Defining and Communicating the Discipline's Core Properties. MIS Quarterly 27(2), 183–194 (2003)
10. Alexander, C., Ishikawa, S., Silverstein, M.: A Pattern Language. Oxford University Press, New York (1977)
11. Baldwin, E., Curley, M.: Managing IT Innovation for Business Value. Intel Press (2007)
12. Sein, M., Henfridsson, Purao, S., Rossi, M., Lindgren, R.: Action Design research. MIS Quarterly Vol 35(1), 37–56 (2011)
13. Nandhakumar, J., Avison, D.: The fiction of methodological development: a field study of information systems. Information Technology and People 12(2) (1999)
14. Wareham, J., Gerrits, H.: De-contextualising competence: Can business best practice be bundled and sold? European Management Journal 17(1), 39–49 (1999)

15. Wenger, W., McDermott, R., Snyder, W.M.: Cultivating communities of practice. Harvard Business School Press, Boston (2002)
16. Brown, J.S., Duguid, P.: The Social Life of Information. Harvard Business School Press (2000)
17. Waterson, P.E., Clegg, C.W., Axtell, C.M.: The dynamics of work organization, knowledge and technology during software development. International Journal of Human-Computer Studies 46(1), 79–101 (1997)
18. Gamma, E., Helm, R., Johnson, R., Vlissides, J.: Design Patterns: Elements of Reusable Object-Oriented Software. Wesley (1994)
19. Gamma, E., Helm, R., Johnson, R., Vlissides, J.: Design Patterns: Elements of Reusable Object-Oriented Software. Addison-Wesley (1994) ISBN 0-201-63361-2
20. van Aken, J.E.: Management Research Based on the Paradigm of the Design Sciences: The Quest for Field-Tested and Grounded Technological Rules. Journal of Management Studies 41(2), 219–246 (2004)
21. Romme, A.G.L., Endenburg, G.: Construction Principles and Design Rules in the Case of Circular Design. Organization Science 17(2), 287–297 (2006)
22. Romme, A.G.L.: Making a difference: Organization as design. Organization Science 14, 558–573 (2003)
23. Ashurst, C.: Benefits Realization from Information Technology. Palgrave Macmillan, Basingstoke (2012)
24. Thompson, Walsham: Placing knowledge management in context. Journal of Management Studies 41(5), 725–747 (2004)
25. Vaishnavi, V., Kuechler, W.: Design Science Research Methods and Patterns. Springer (2008)
26. Curley, M.: Introducing an IT Capability Maturity Framework. In: Cardos, J., Cordeiro, J., Filipe, J. (eds.) ICEIS 2007. LNBIP, vol. 12, pp. 63–78. Springer, Heidelberg (2007)
27. Curley, M.: The Emergence and Initial Development of a New Design Pattern for CIOs Using Design Science. In: Helfert, M., Donnellan, B. (eds.) EDSS 2011. CCIS, vol. 286, pp. 1–14. Springer, Heidelberg (2012)
28. Curley, M.: The IT Capability Maturity Framework. PhD Dissertation, National University of Ireland, Maynooth (2008)
29. Curley, M., Kenneally, J.: The IT Capability Maturity Framework, Innovation Value Institute, National University of Ireland, Maynooth (2009, 2010)

Design, Thinking and Science

Frank Devitt[1] and Peter Robbins[2]

[1] Department of Design Innovation, National University of Ireland Maynooth, Ireland
frank.devitt@nuim.ie
[2] School of Business, National University of Ireland Maynooth, Ireland
peter.robbins@nuim.ie

Abstract. Research and education in the field of management studies strive for relevance to practice as well as academic rigour. Many management science researchers have invoked design science as the paradigm of choice for achieving relevance through prescription-oriented research, where prescriptions are delivered in the form of artefacts or technological rules. Design thinking is another prominent application of design that is used by management researchers and educators for benefitting management practice. Surprisingly, there is little intercourse between the different groups that employ these two approaches, yet both groups are part of the same broad (management study) discipline. Here, we explore the relationship, commonalities and complementarities between design thinking and design science. We do this in the context of an introduction to the broader discipline of design and its history, the desire of management scholars to be relevant to practice, and the nature of that practice. We show that design thinking and design science are complementary components of an overall design paradigm. The appropriate application of either approach depends on the context and nature of the problem being addressed.

Keywords: Design Thinking, Design Science, Design, Innovation, Management Science Research.

1 Introduction

Researchers in management science and other social sciences increasingly look for the outputs of their research to provide value directly to practitioners of the field, in addition to satisfying the rigours of quality academic scholarship. Such research seeks to prescribe general solution concepts for practical contexts. In general, these contexts have been understood and analysed through traditional research with a more explanatory orientation.

The literature discussing this topic describes the general solutions as artefacts or technological rules. According to Tranfield, quoted in Huff et al [1], technological rules are products of research that "provide archetypal solutions to archetypal problems". Such technological rules or artefacts are ipso facto the outputs of a design process, and many researchers have embraced design science as the paradigm to effect the aim of practitioner relevance. Design science has accrued a substantial literature and there is a developing understanding amongst its practitioners as to what it is, what it isn't, and what it entails. This paper contributes to this understanding.

M. Helfert and B. Donnellan (Eds.): EDSS 2012, CCIS 388, pp. 38–48, 2013.
© Springer International Publishing Switzerland 2013

Herbert Simon represented the universal nature of design as a science of the artificial. His was primarily a positivist, rationalistic paradigm that focussed on design as a science. We understand ‘science’ here to denote an objective, coherent body of knowledge obtained and validated by rigorous rationalist methods.

Equally, the broader design community has a voluminous literature on the nature of design, describing the way that its focus and theories have developed over the last century. Bousbaci [2] describes this development in terms of the ‘models of man’, analogous to the ‘homo-economicus’ or ‘rational’ man that was implicit in the traditional study of economics prior to Simon’s introduction of the concept of bounded rationality. According to Bousbaci, the model of man implicit in design discourse prior to 1950s was of an intuitive and artistic designer. This gave way in the late 1950s to a logical and rationalist model, which is the antecedent of modern design science. Through the 1980s, the design model took its lead from Simon and took a bounded rationality perspective. This transformed again in the 1990s to the model of designer as a reflective practitioner who engages in a ‘conversation’ with materials and users, after Schön [3].

2 Design and Science

It is not in the scope of this paper to review in full the literature on the philosophies and models of design. But, it is clear that the totality of contributions on this subject comprehend design as being more than a rationalist or positivist science. This is in line with popular perceptions of design, we believe, where creativity, intuition and human-interactivity would be high on the list of defining design characteristics.

A broadly understood model of design concerns itself with human behaviours, attitudes, values and sensibilities in addition to product characteristics, meanings and styles. This is not just in the public perception. Scholars such as Cross [4], Bousbaci [2], Findeli [5] and others agree. Cross [4] poses the question about “… the development, articulation and communication of design knowledge. Where do we look for this knowledge?” In response, he says that design knowledge has three sources: “people, processes and products. Design knowledge resides firstly in people: in designers especially, but also in everyone to some extent.”

Regarding products, Cross says:

> “… we must not forget that design knowledge resides in products themselves: in the forms and materials and finishes that embody design attributes. Much everyday design work entails the use of precedents or previous exemplars - not because of laziness by the designer but because the exemplars actually contain knowledge of what the product should be.

He elaborates:

> “My own taxonomy of the field of design research would therefore fall into three main categories, based on people, process and products:
>
> *Design epistemology* - study of designerly ways of knowing
> *Design praxiology* - study of the practices and processes of design
> *Design phenomenology* - study of the form and configuration of artefacts”

In contrast, process, content and objectivity are the major concerns of science. The processes must show rigorous verification or falsifiability of new knowledge (Popper [6]). Besides the generation and verification of knowledge, good science must be concerned with the classification, cohesion and coherence of the knowledge base. As well, positivist science presumes an independent, objective truth that has existence outside of the person or artefact. Design does not presume this; it concerns itself with the ill-definition and uncertainty of holistic problem solving or complex situation improvement. In order to do this, relevant knowledge is recognised to be incorporated in the agent of design as well as in the artefact itself.

3 Design Thinking and Design Science

From the above brief history and overview of design, the apparent dichotomy in the characterisation of design between intuitive, relativist artistry on the one extreme and rational, positivist science on the other extreme suggests that there may be more than one way that design can act as medium for management studies to bring beneficial relevance to management practitioners. This is indeed the case. The latter (rationalist) type of design is mediated in the form of design science; the former (intuitive) type of design is mediated in the form of design thinking.

Design Thinking concerns itself with the "study of the cognitive processes that are manifested in design action" [6]. On the other hand, design science adapts the *process* of design to the scientific method requirements of management science research. In contrast to design science for research, design thinking emphasises design's ability to deal with human sensitivities, socio-cultural understanding, uncertainty and integrative treatment of ill-defined problems, which are more characteristic of the 'messy' field of management practice and most especially for innovation management.

In this paper, we epitomise the key distinction between design thinking and design science in the sphere of management studies as follows. Design science adapts and supplements the methodical, positivist and rationalist methods, which are used in everyday designing, as a methodology for prescription oriented social science research, the output of which is brought to contexts of social science practice through a growing bank of fully annotated objective knowledge.

Design thinking harnesses and develops the intuitive, creative, integrative, visual-thinking, constructivist facets of expert design practice and brings these to complex and 'wicked' contexts of practice, through the agency of the human practitioners. Similar to *Star Trek*, 'the mission of design thinking is to boldly go where no science has gone before – or is likely to go in the near future'.

Both design thinking and design science are derived from design and aim to support management studies' relevance. Yet, very surprisingly, there is little intercourse between the two fields. It is difficult to find a publication that refers to both design science and design thinking. Cross [4] describes the 'designerly' way of thinking as different and complementary to a science way of thinking, in the context of the historical development of design philosophy as described above. Anderson et al [9] provide a description of an application of design science to Chevron's innovation process that comes close to linking the two but fails to do so explicitly. Other examples are rare.

We might speculate that the absence of intercourse and cross referencing between the exponents of design thinking and design science must be due to a lack of mutual familiarity, understanding or respect. If true, this is sadly ironic. Both draw from the rich well of design's legacy with the same ultimate purpose.

Both are approaching the same goal from different perspectives. The positivist perspective of design science regards its core operational contributions as artefacts that accumulate the knowledge base. There is an implicit assumption that the knowledge is objective and to some extent generalisable.

In its core functioning (i.e. doing it as distinct from studying about it), design thinking is embodied in the design thinker, in terms of behaviours, values, attitudes, intuition, creativity. This is a relativist and constructivist perspective where knowledge is primarily resident in the thinker or context. Of course, the latter is more suited to situations which are individually unique or 'messy'[3], as are many practical contexts and all wicked problems.

As an aside, it is sometimes forgotten that a university's role is to teach, i.e. to form students' minds, in equal or even higher measure as to research. Newman [15], in his seminal work The Idea of a University (1842), said:

> "[A university] is a place of teaching universal knowledge. This implies that its object is … the diffusion and extension of knowledge rather than the advancement [of knowledge]. If its object were scientific and philosophical discovery, I do not see why a University should have students …"

Of course, research is nowadays understood to be an essential and important role. In principle, it is clear that the practice of design science and design thinking respectively prioritise the two roles of research and teaching, and that they complement each other in so doing. Of course, to support a design thinking expertise for teaching, it is in turn necessary to research the topic itself and this is a growing research area.

3.1 Modelling Design Science

Hevner et al [10] describe the characteristics of good design science research and provide seven guidelines for conducting and evaluating good design science research. These are problem relevance, design evaluation, research contributions, research rigour, design as a search process, communication of research.

More succinctly, Hevner [8] describes a three-cycle view of design science research. This is replicated with some adaptation of layout in figure 1. He describes it thus:

> "The relevance cycle bridges the contextual environment of the research project with the design science activities. The rigor cycle connects the design science activities with the knowledge base of scientific foundations, experience, and expertise that informs the research project. The central design cycle iterates between the core activities of building and evaluating the design artefacts and processes of the research."

Hevner posits that "these three cycles must be present and clearly identifiable in a design science research project".

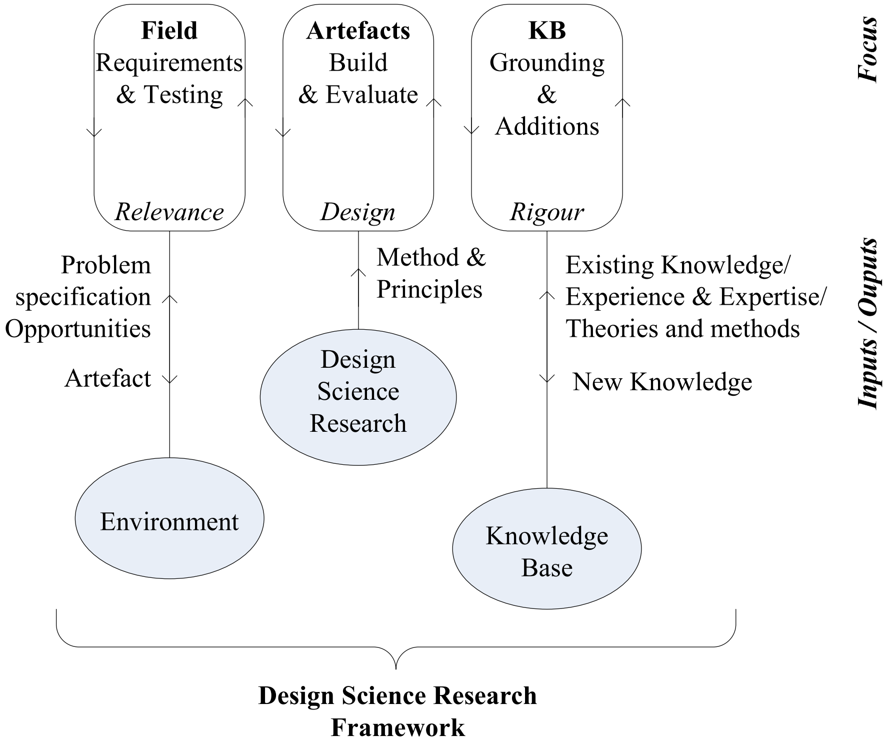


Fig. 1. A Three Cycle View of Design Science Research, adapted from Hevner [8]

3.2 Characterising Design Thinking

Capturing the essence of design thinking is still a matter of substantial research and debate.

Cross [4] describes research work that supports "a solid basis for the claims of expert, designerly ways of knowing thinking and acting". He concludes,

> "there are enough commonalities in the behaviours of outstanding designers to suggest a view of expertise in design that has its own particular features, with some differences from generic models of expertise, which have been mainly drawn from studies in more conventional types of problem solving."

He found that expert designers often exhibited a distinct set of cognitive strategies, such as:

- Generating a range of alternative solution concepts.
- Having an ability to work along 'parallel lines of thought' – that is, to maintain an openness, even an ambiguity, about features and aspects of the

design at different levels of detail, and to consider these levels simultaneously, as the designing proceeds.

- Relying explicitly or implicitly upon ‘first principles’ in both the origination of their concepts and in the detailed development of these concepts.
- Exploring the problem space from a particular perspective in order to frame the problem in a way that stimulated and pre-structured the emergence of design concepts. In some cases, this perspective was a personal one that the designers seem to bring to most of their designing.
- Creative design solutions arise especially when there is a conflict to be resolved between the designer's own high-level problem goals (their personal commitment) and the criteria for an acceptable solution established by client or other requirements. The outstanding designers are able to draw upon a high-level, or more systemic view of the problematic in which their actions are situated.

Martin [12] also identifies integrative thinking as a key designerly characteristic that is also found in great business leaders, in his book ‘The Opposable Mind: How Successful Leaders Win Through Integrative Thinking’. Elsewhere, Martin [11] says that: "The most successful businesses in the years to come will balance analytical mastery and intuitive originality in a dynamic interplay that I call design thinking.”

The Stanford d.school represents its design thinking philosophy using the graphic shown in figure 2, which shows the elements of a design thinking ‘process’. There has been much discussion about the apparent sequential linearity of this image and similar images. The linear representation should not be misunderstood as misrepresenting the profoundly iterative nature of all design thinking projects. It is now generally considered that the image represents different modes of working rather than sequential steps of a process, while recognising that there is a *shift in centre of gravity of attention* from left to right as a project progresses. The iterative nature is represented by the swirls between modes.

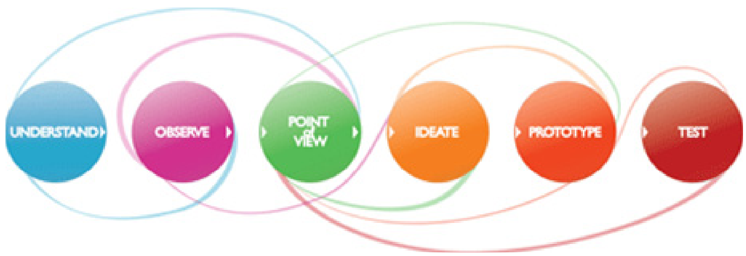


Fig. 2. Stanford d.school Model of Design Thinking

Lindberg et al [13] describe a constructivist approach to design and design thinking resolution of ‘problems’. They describe design thinking as the interplay between diverging activities of opening up the problem and solution space and converging activities of synthesising and selecting.

> "Contrary to scientific thinking, the knowledge processed in design thinking has to be neither representative nor entirely rationalised, rather it serves to obtain an exemplary but multi-perspective understanding in order to creatively transform it to a solution for the ambiguity of wicked problems.
> Summing up, this interplay can be put down to three basic characteristics, that engenders a system of checks and balances to ensure that the conclusive solution will be both innovative and suitable for the social system that the design problem addresses."

The three basic characteristics are identified as:

- Exploring the problem space
- Exploring the solution space
- Iterative alignment of both spaces.

Brown [14] says some of the characteristics to look for in a design thinker are:

- Empathy
- Integrative thinking
- Optimism
- Experimentalism
- Collaboration

Most contributors on the subject believe that visualisation is an essential part of the design thinking repertoire. Buxton [16] pose the question: "What is the archetypal activity of design?", and offers the answer: sketching or drawing. More broadly, Stanford's d.school emphasises the necessity to 'think visually' in design thinking project.

4 An Integrated Model

Two approaches with a shared purpose and a common origin deserve to be connected, have overlaps identified, distinctions clarified and their separate application paradigms explained. In figure 3 we make a step in this direction, where we adapt and extend the three-cycle model of design science (figure 1) to develop a similarly structured representation of design thinking (figure 3).

On the right hand side of figure 3, we note that an objective knowledge base plays a lesser role in design thinking. The knowledge base built up by design science, natural science and other sources forms a sort of toolbox, from which the designer (or design thinker) may draw or not, according to the context. The knowledge base also may be considered as objective constraint laws, around which the design thinker must creatively design.

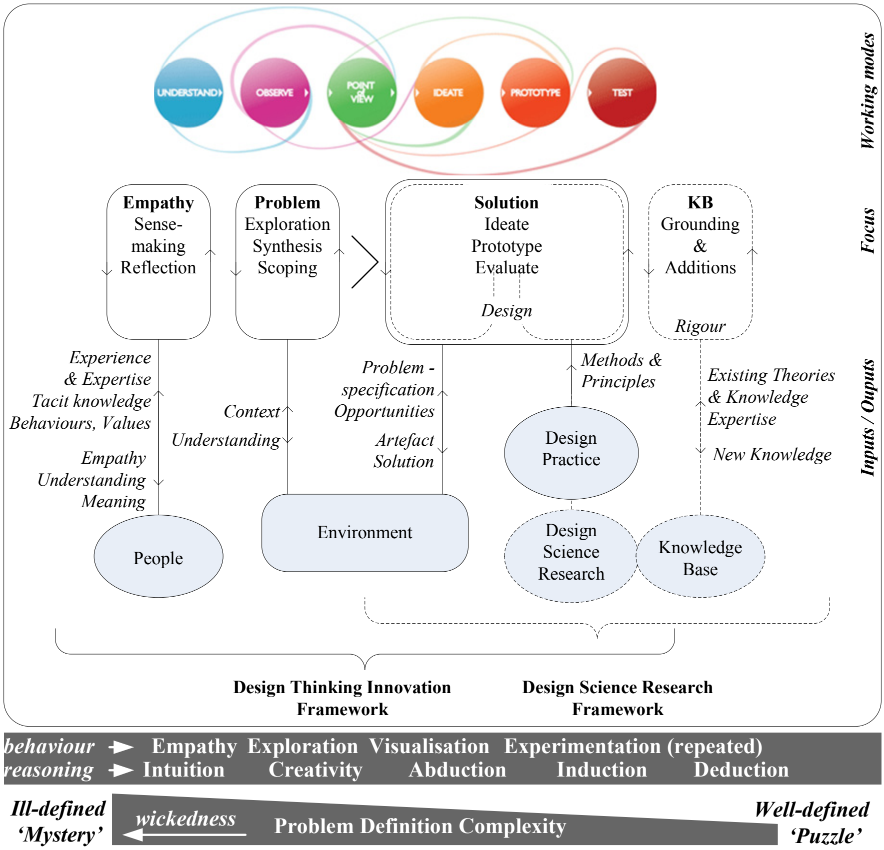


Fig. 3. Design Thinking Innovation Framework, incorporating the Three Cycle View of Design Science

Moving towards the left in figure 3, we note that design thinking is more fruitfully applied to contexts that are not replicable in 'laboratory' or standardised situations and therefore the separation of evaluation fields between 'research lab' and 'field' does not apply. For design thinking, the environment or 'field' is the major evaluation locus for the proposed solution.

The two leftmost regions of figure 3 provide the most distinguishing aspects of design thinking. Design thinking is most applicable for complex 'messy' or wicked problems, for which a simple or even reliable statement of the problem may not be accessible. Deep exploration and creative synthesis of data from the problem space is integral to the design thinking methodology.

Perhaps above all else, design thinking is characterised and may be understood by its human centricity. Human considerations and sensibilities are fully central to the design thinking approach, in terms of stakeholder understanding, empathy, creativity and co-creation. As referenced above, much of the design thinking knowledge is embedded in the 'designer'. Radical or breakthrough solutions in 'messy' contexts rely on the designer's intuition, abductive and creative abilities. These are honed by expertise developed through education and experience, and refined by immersion in the present context. Design thinkers thrive on the dialectic with co-designers, users, and other stakeholders and use this to painstakingly evolve the true integrative optimum resolution for all concerned. Design thinking is intrinsically collaborative.

5 Design Thinking in Action

We provide below a summary example of a recent design thinking approach to a real-life problem situation, in which one of the authors participated. This case-study will be reported in full elsewhere.

Merrion Square in Dublin is a great Georgian square dating back to the 1750s. Merrion Square is home to many of the main cultural institutions in Ireland, including the national gallery, the natural history museum, the Irish parliament. Augmenting the impressive treasures around the square itself is an outer ring of institutions, buildings, activities which include the national library, the national museum, Royal Hibernian Association and many of the city's most prestigious hotels and restaurants. It is also a thriving commercial hub with many of the country's leading creative PR agencies, architects and advertising firms located around it.

The Irish tourism agency, Failte Ireland, have been keenly aware that the cultural and architectural treasures of Merrion Square were not being exploited for the benefit of visitors, local businesses and institutions or national tourism. This is represented by the coaches of tourists that would regularly converge on Merrion Square to photograph the collection of unique Georgian architecture and front doors with grand, elegant fanlights. Ironically, the most common photograph is of tourists standing beside closed doors.

The Innovation Manager of Failte Ireland decided, in Autumn 2011, to adopt a design thinking approach to improving this situation. She thought that design thinking had the capacity to bring the stakeholders together. It could generate new ideas to bring new animation, energy and activities to the square, to visualise them, to prototype them and to garner support for their introduction or implementation.

Failte Ireland invited over 40 cultural and business institutions to join a new innovation network where they would get to meet each other and work together in their individual and joint interests. Through the network, Failte Ireland provided some expert design thinking innovation training. Members of the network were invited to attend four day-long workshops where they learnt how to enhance their individual and collective design thinking capability. The workshops taught them the design-thinking approach to innovation and helped them generate new ideas to bring new vibrancy into the square and, of course, to their own businesses. Customers were also invited to the innovation workshops and ideas were developed, illustrated, prototyped (where possible) and road-tested with consumers in a rapid-prototyping manner.

Since early 2012, the workshops have begun to have immediate effect and the activities around Merrion Square have been constant. Springtime saw thousands of people converge in the square for the World Street Performing Championships; St Patrick's Day brought a new and bigger-than-ever festival. Culture Night came to Merrion Square with thousands of visitors visiting buildings which had never been opened up before this year. Major events are taking place for Christmas and Hallowe'en and the park has been designated by the City Council as a free wi-fi zone. A new group called 'Supper on the Square' has been formed and there are monthly dinners hosted and catered in some of the great houses on the Square. Much more is planned.

This case illustrates the power of design-thinking in a collaborative, social innovation context. The project implementation used the design thinking principles of user-centricity, visualisation, intense collaboration and rapid prototyping. It has accomplished a great deal in a very short time. Within the Square two things have been developed: first, a new capability to innovate and second a suite of new ideas to add value to the stakeholders collectively and individually.

6 Summary and Conclusions

Over the last 30 to 40 years, two strands have emerged as powerful tools in the problem-solving armoury of management studies and innovation. Design Thinking is a mode of cognition and a methodology to imagine and bring into effect future states and to bring radical products, services, experiences and solutions to market (or to application context). Its key principles are that is people-centred, involves deep collaboration, and relies on dialectics, visualisation, prototyping and fast experimentation.

Design Science is a paradigm of management science research that supports generation of valid prescription outputs from that research. The validity is determined through rigorous theoretical grounding in academic discourse and field testing in the relevant environment.

Both strands owe their origins to 'design'; both strands operate in the broad field of management studies – teaching and research; both strands purport to aspire to solving problems in the sphere of practice.

We have shown that, notwithstanding many commonalities, there are substantial complementarities and that it is the combination of the two approaches that begins to approximate a fuller application of design to management studies and its relevance. We have shown that each approach is more suited to resolution of problems that tend towards respectively opposite ends of the 'problem complexity' spectrum.

Design science is adapted especially towards the specifics of management science research, with primarily a positivist philosophy where objective knowledge is metaphorically accumulated in a knowledge resource bank, for later use by practitioners. Design thinking is especially suited to the more wicked type of complex problems where intuition, abductive and creative thinking and methodologies are necessary, which are based on internal, tacit knowledge of the (co-)designers. Notwithstanding this, familiarity with the objective knowledge base of management science and other sciences serves as essential constraint for such design thinking.

This paper has shown that design thinking and design science are complementary components of an overall design paradigm. Each has particular attributes that make it more suitable to be the dominant methodology in a particular context. Design science is the primary methodology of choice for research of better-defined problem areas. Design thinking is more suited to ill-defined problems.

By understanding their commonality and complementarities, as outlined in this paper, exponents of both strands of design in management may be encouraged to understand and communicate with the other strand to a greater extent than heretofore seems to have been customary. Neither one nor the other strand alone will adequately satisfy the purpose of beneficial relevance to management practice. In modern management studies, both strands must be represented strongly for best effect.

References

1. Huff, A., Tranfield, D., van Aken, J.E.: Management as a Design Science. Journal of Management Enquiry 15(4), 413–424 (2007)
2. Bousbaci, R.: “Models of Man” in Design Thinking: The “Bounded Rationality” Episode. Design Issues 24(4) (2008)
3. Schön, D.A.: Reflective Conversation with Materials - an interview with Donald Schön by John Bennett, Bringing Design to Software. Addison-Wesley (1996)
4. Cross, N.: From a Design Science to a Design Discipline: Understanding Designerly Ways of Knowing and Thinking, Design Research Now, Board of International Research in Design, Berghauser AG (2007)
5. Findeli, A., Bousbaci, R.: L’Eclipse de L’Objet dans les Théories du Projet en Design (The Eclipse of the Object in Design Project Theories). The Design Journal 8(3), 35–49 (2005)
6. Cross, N., Dorst, K., Roozenburg, N.N.: Preface to Research in Design Thinking. Delft University Press (1992)
7. Popper, K.: The Logic of Scientific Discovery. Hutchinson & Co. (1959)
8. Hevner, A.R.: A Three Cycle View of Design Science Research. Scandinavian Journal of Information Systems 19(2), 87–92 (2007)
9. Anderson, J., Donnellan, B., Hevner, A.: Exploring the Relationship between Design Science Research and Innovation: A Case Study of Innovation at Chevron. In: Helfert, M., Donnellan, B. (eds.) EDSS 2011. CCIS, vol. 286, pp. 116–131. Springer, Heidelberg (2012)
10. Hevner, A., March, S., Park, J., Ram, S.: Design Science in Information Systems Research. MIS Quarterly 28(1), 75–105 (2004)
11. Martin, R.: The Design of Business; Why Design Thinking is the Next Competitive Advantage. Harvard Business School Press (2009)
12. Martin, R.: The Opposable Mind: How Successful Leaders Win Through Integrative Thinking. Harvard Business Review Press (2007)
13. Lindberg, T., Gumienny, R., Jobst, B., Meinel, C.: Is there a need for a Design Thinking Process? In: Proceedings of the 8th Design Thinking Research Symposium, DTRS8 (2010)
14. Brown, T. (2008). Design Thinking. Harvard Business Review (June 2008)
15. Newman, J.H.: The Idea of a University, Dublin (1852), Preface
16. Buxton, B.: Sketching User Experiences. Morgan Kaufmann Publishers (2007)

Activity Cycles in Design Research: A Pragmatic Conceptualisation of Inter-related Practices

Göran Goldkuhl

Department of Management and Engineering, Linköping University, Sweden
goran.goldkuhl@liu.se

Abstract. There has been a great interest among scholars to identify and conceptualise activities and processes of information systems design research. Based on a paradigmatic foundation in pragmatism, this paper furthers these earlier works on activities and processes. It identifies three main sub-practices of design research; theorize, build and evaluate. It also identifies three external practices/communities: research community, general practice and local use practice. The different practices are related to each other through the construct of an activity cycle. Seven different activity cycles are specified in the paper: Theorize – Build cycle, Theorize – Evaluate cycle, Build – Evaluate cycle, Theorize – Research community cycle, Design research – General practice cycle, Build – Use cycle and Evaluate – Use cycle.

Keywords: Design research, information system, practice, pragmatism.

1 Introduction

The interest in design research (DR) within the information systems (IS) community has been growing over the last decade. It has been seen as a research approach that encourages an interest in practical outcomes and improved practice, and thus for enhanced practical relevance. There are many attempts to conceptualise DR, e.g. [1], [2], [3], [4], [5], [6], [7] and [8], showing great diversity. This diversity may be explained that the paradigmatic foundations for design research have not yet settled. There have been suggestions to position DR within interpretivism [9] and critical realism [10]. There have been several attempts to position DR within pragmatism [11], [12], [13], [14], [15], [16], [34]. Pragmatism emphasises action, change and practical use, which makes it an appropriate paradigm candidate. There are valid arguments to position design research within pragmatism since DR:

- Addresses real life problems.
- Attempts to create artefacts of practical value (utility).
- Contributes to practice improvement.
- Is engaged in interaction between academia and practice.

This paper takes pragmatism as a suitable research paradigm for design research for reasons mentioned above and following the suggestions of [11], [12], [13], [14].

M. Helfert and B. Donnellan (Eds.): EDSS 2012, CCIS 388, pp. 49–60, 2013.
© Springer International Publishing Switzerland 2013

The intention is to try to create a meaningful conceptualisation of DR based on pragmatic perspectives and constructs. The main idea is to identify sub-practices of design research and try to relate them to each other. In doing so, the paper uses the idea of activity cycles borrowed from [11].

The main purpose of this paper is thus to contribute to the conceptualisation of design research based on pragmatic foundations. It can be characterised as a conceptual inquiry and is driven by a problematic situation that needs resolving [17].

There is still confusion and conflict concerning how to view design research; e.g. the processes and outcomes of DR [3], [4]; the role of theory and theorizing [18], [19]; the relation between design research and design practice [20], [21]; the role and character of evaluation and validation [8], [23], [24]; the relation between DR and intervention [5], [24]; what is included DR and not [20]. There is also confusion with regard to what to call this research approach: design research, design science research or design science. I will use the term design research throughout this paper.

Part of this conceptual diversity of DR will be investigated in section 2 below as a basis for the conceptualisation made in section 3. This paper represents an initial step of practice conceptualisation and it should be followed up by more empirically-focussed research. In proposing this DR conceptualisation, the author is influenced by several years of empirically oriented DR. However, these empirics are not brought explicitly into the paper, but form a tacit background. As stated, the next step of this research is to conduct empirical grounding for this practice conceptualisation.

2 Attempts to Conceptualise Design Research

There have been many attempts to conceptualise design research. One salient contribution is the division of DR into two main activities: build and evaluate [2], [3], [11]. There are several proposals of extensions of this basic DR division. Offerman et al [6] have added problem identification to the build and evaluate activities. Sein et al [5] have made another expansion of build and evaluate. In an attempt to integrate DR with action research, they have added intervention as a third core activity, although these three activities are kept together in an integrated way in “BIE cycles”. They also include problem formulation as well as reflection and learning in DR. There are also further expansions of DR activities into prescriptions of DR processes. Peffers et al [4] describe a six step DR process consisting of problem identification, objective definition, design, demonstration, evaluation and communication. The classical paper by Nunamaker et al [1] also contains a process description consisting of five steps; three design steps in the middle are surrounded by an initial conceptualisation and a concluding evaluation. Another proposal for the DR process can be found in [7] where the DR process consists of five steps: problem awareness, suggestion, development, evaluation and conclusion. There are already integrative approaches that try to combine and condensate previous process proposals, e.g. [6], [8]. However, in these detailed process descriptions, the different activities are grouped together mainly using the build – evaluate division. This means that the original build – evaluate dichotomy seems valid and useful for describing DR, although there will of course exist many identifiable and related activities. Several of these other identified DR activities can thus be seen as sub-activities of build or evaluate.

The build – evaluate descriptions of DR seem to have a focus on the generation of the design artefact. This is, however, interpreted as a limited view of DR. The prevailing view [3], that the main result of DR is the designed artefact, has been questioned by several scholars. The importance of creating abstract knowledge besides concrete artefacts is contended by [20], [21], [25], [26]. The DR process models accounted for above can be said to be linear, one-level process models, e.g. [1], [4]. Alternatives are formulated with two interacting levels; one concrete design level and one abstraction level [21], [25], [26], [27]. This is fully in line with the suggestions made by many advocates of design theory in DR, e.g. [7], [18], [19], [28], [29]. If one scrutinizes the process models mentioned above, in some there are elements that point to abstraction and theorizing and not to concrete design. Examples of this are: learning and reflection [5], conclusion [7] and communication [4].

Some part of the diversity of DR activities and processes has been mentioned briefly above. They all give their valuable fragments to our required understanding of what we, as researchers, do when we conduct design research. The DR process models have been put forth with the ambition to be comprehensive; e.g. [4], [5], [6], [7], [8]. However, these models do not fully take into account the interaction between concrete design and abstraction/theorizing. We still need a DR conceptualisation that acknowledges, in a clear way, the dual DR purposes of contributing to 1) practical problem solving through design of artefacts and 2) the knowledge goals of a scientific community [21] in a clear way.

3 A Pragmatic Conceptualisation of Design Research

The selected way to move forward in conceptualising design research is not to make a comprehensive listing of possible DR activities in order to arrive at a complete DR process. The approach taken is to identify core sub-practices of DR and to clarify relations between these sub-practices and also relations to surrounding practices. This approach follows a general practice-orientation of this research. Design research is in itself considered a practice; a research practice [30]. A practice is considered to be "embodied, materially mediated arrays of human activity centrally organized around shared practical understanding" [35, p 2]. Even if a practice sometimes can be performed by one human actor at a time, these activities and their results should be seen as based in a shared inter-subjective understanding. A practice is a social phenomenon. A practice consists usually of constellations of actors, actions and objects [36]. Important to add is that a practice produces results that is considered valuable to some actors. A practice means doing something in favor of some people [36].

3.1 Meaningful Sub-practices of Design Research

The current ambition is thus to have a small set of sub-practice and find a few main sub-practices of DR. Since design research is in itself an artificial workpractice, there is no right division of sub-practices. There is no possibility to find the correct delineation of practices. We must instead find a suitable and adequate division and delimitation. In the search for primary sub-practices, the well-known divisions of build and evaluate seems to be proper candidates. There are many DR references that either argue for these two as core DR activities or simply take them for granted. A design/build activity is obvious in DR since the whole idea is to design artefacts. However, there almost seems to be a consensus among DR scholars that a build activity should be supplemented by evaluation activities. Most scholars claim evaluation to be a clearly identifiable and separate activity (e.g. [3], [22]). There are however, some scholars [5] who see evaluation as an integrated part of building artefacts. I can agree that there should be a continual assessment of design proposals which should be conducted directly related to the design situation. However, there seem also to be obvious needs for separate and distinct evaluation activities; confer figure 1.

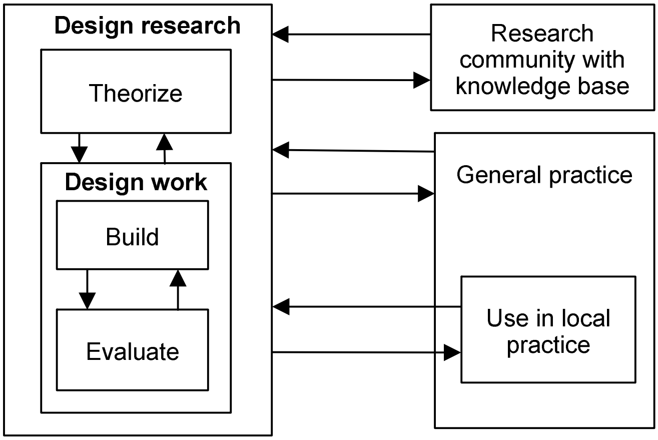


Fig. 1. Sub-practices of design research and relations to surrounding practices/communities (with inspiration from [3], [21], [30])

As discussed in section 2 above, there are many scholars who claim that there should be a clear theoretical output from DR which means that there should be clearly distinguishable theoretical activities within DR. There are several scholars who describe DR in two layers [21], [25], [26]; one design-oriented and one oriented towards theorizing and abstraction. This differentiation into theorizing and concrete design is important when clarifying DR practices. In [26] the two realms are called "abstraction domain" vs. "instance domain". In [21] the two realms are called "meta-design practice" vs. "design practice". In order to be explicit about its theory generating purpose I will call this sub-practice theorize below. The two other activities of build and evaluate can be grouped under the label design work corresponding to "instance domain" [26] and "design practice" [21]. However, in the following, build and evaluate will constitute two sub-practices, and theorize will thus be the third sub-practice of DR; confer figure 1.

These three sub-practices will be based on different *cognitive orientations*. The build practice will be based on a *design orientation*; the creation of tangible artefacts that are intended to be practical and useful. The evaluate practice will be based on an *inquiry orientation*; i.e. investigating something and stating something about it. Evaluate takes an artefact as an input and based on some investigation and assessment it produces statements concerning this artefact. Theorize will be based on an *abstraction orientation*. Abstract knowledge is created concerning some phenomenon. Each of these sub-practices produces results that should be valuable to other practices.

3.2 External Practices to Design Research

The next question to deal with is what type of external practices exist and are related to design research and its three sub-practices. Hevner et al [3] distinguish two realms that IS design research relates to; the knowledge base and environment (consisting of people, organizations and technology). This means that the research activities of DR interact with a business environment and a science environment. In [21] a differentiation into three related practices/communities are made: 1) Research community, 2) practice community and 3) use situation. Compared with [3] and its business environment, a differentiation is here made between the general practice level and the actual use situations. General practice is defined in the following way: "It is important to note that 'general practice' should be interpreted as a special kind of abstraction. It is not one particular practice. When talking about general practice we mean a set of different practices with relevant similarities." [30, p 10]. This division into the general vs. the local is an important distinction for the continued discussion. In figure 1, these three practices/communities are called 1) research community, 2) general practice and 3) use in local practice. Figure 1 thus includes a division of DR into three sub-practices (theorize, build and evaluate) and defines that DR has relations to three external realms (communities/practices). This is one step towards a pragmatic conceptualisation of DR. The next step will be to define the relations between these different practices.

3.3 The Use of Activity Cycles in Design Research

Hevner [11] uses the view of activity cycles to clarify DR. He speaks of three cycles: The design cycle that iterates between build and evaluate; the relevance cycle that iterates between the DR activities and the practice environment; the rigor cycle that contains the utilisation of extant knowledge in DR and the addition of new knowledge from DR to the knowledge base. This cycle construct states that interaction occurs between two types of activities/practices. There is an exchange of knowledge between the two mentioned activities. However, in [11], or in [3], there is no systematic specification of the knowledge exchange between the two mentioned activities. Some parts of the knowledge exchange are mentioned in running text. As identified above (section 3.1-2) the Hevner DR framework, [3] and [11], operates with fewer practices than the one articulated in this paper. In [3] there is no clear differentiation between general practice and local use practice, and the theorizing sub-practice of DR is not included either.

Earlier attempts to use and develop the cycles of the Hevner framework have been made in different directions. An expansion of the three cycles to four has been made by [27], when adding an abstract knowledge activity within DR that has cycle relations to the design activity; confer similar conceptualisations in [21]. There is a discussion [31] regarding which part (in a DR sub-practice) informs which part (in another DR sub-practice). As concluded, there can be mutual informing processes. Confer also related discussions on inductive vs. abductive approaches in DR [26], [32]. Evaluation will play pivotal roles in DR. As noted by several scholars, e.g. [8], [21], evaluation will interact with both build/design and use and will thus have different functions in relation to these activities. Evaluation will also have an important impact on theorizing [21], [26], [31].

3.4 Design Research Internal Cycles

The governing idea in this pragmatic conceptualisation of DR is to clarify the primary knowledge exchange that may occur between the different sub-practices. Activity cycles between sub-practices will be specified. In a pragmatist spirit, the different sub-practices are conceived as functional in relation to each other. This means that the starting-point in the analysis below is that there is a mutual interchange and serving. Practice A serves practice B with some knowledge and practice B serves practice A with some knowledge. These mutual serving processes are conducted through the activity cycles. The interaction within the activity cycles can in several cases be seen as initiatives and subsequent responses to these, following the well-known construct of adjacency pair from conversation analysis [33]. The three sub-practices of design research give rise to three activity cycles (figure 2):

- Theorize – Build cycle (T-B)
- Theorize – Evaluate cycle (T-E)
- Build – Evaluate cycle (B-E)

Design research can be performed in a theory-informed way. Fischer et al [32] describes this as one possible option, in DR, as an abductive approach; confer also [26]. Sein et al [5] emphasize that the designed artefact should be a theory-ingrained artefact. This means that theories can be used actively in DR governing both build and evaluate. This is called theory as guidance in figure 2. The theory as guidance covers both descriptive-explanatory “kernel” theories [18] and design-oriented theories [18], [19]. It covers also the cases 1) when extant theories from the knowledge base are selected and possibly adapted to the DR situation and 2) when ideas, observations and reflections from the on-going DR process is abstracted to an emergent theory that can then be fed back to build and evaluate from theorize. Besides such empirical data, the build practice will produce the designed artefact as its main output to theorize. In the view of DR put forth here this is pivotal. It is not the artefact per se that is the scientific contribution from DR. It is abstracted knowledge about artefacts [21], [26]. The artefact from build is an artefact to theorize. The theorize sub-practice will create abstract knowledge about artefact functions, structure and other properties. These abstractions may be fed back to design work, but they will also be a distinct outcome from DR to practice and research communities (see section 3.5 below).

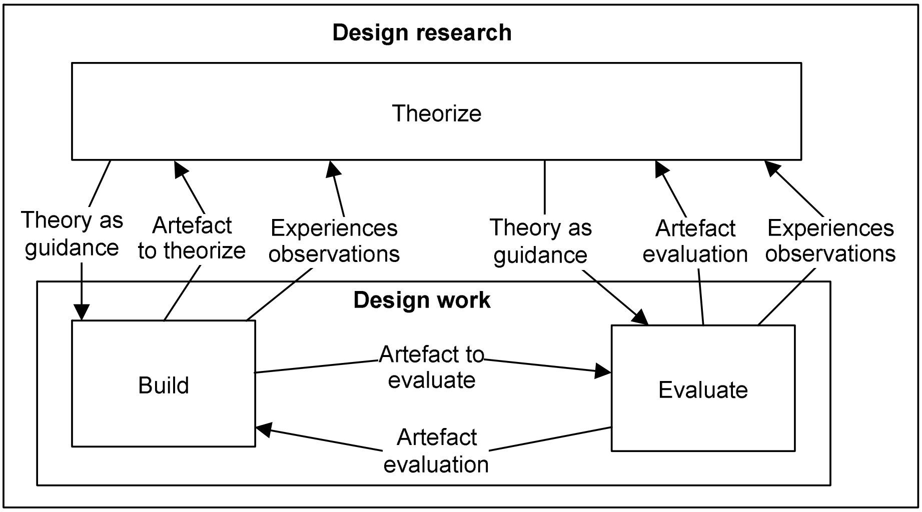


Fig. 2. Activity cycles of design research (internal cycles)

An important input to theorize is the explicit evaluations that will be conducted as part of the design work. There may be different types of evaluations; e.g. an artificial evaluation of a proposed artefact or a naturalistic evaluation of the real use of designed artefacts [8], [22]. Such evaluations will have an important function in empirical grounding of the abstract design knowledge in the theorizing practice [21].

The main input from theorize to build and evaluate is said above to be theory as guidance. Theory is here used in a generic sense. It should not be interpreted literally as only *one* theory. There can of course be different theories; both extant and emergent theories and both kernel theories and design theories, as indicated above. One important basis for further theorizing and justification of these theories is the experiences of theory use in build and evaluate. Were these theories applicable in building and evaluating? How useful were they in these activities?

3.5 Design Research External Cycles

Design research interacts also with external practices (figure 1). The three DR practices and the three external practices make it possible to distinguish nine cycles (3*3) if all internal practices are seen as having relations to all external practices. However, it is not considered meaningful to make this kind of elementary division. Instead four main activity cycles are distinguished (figure 3):

- Theorize – Research community cycle (T-RC)
- Design research – General practice cycle (DR-GP)

- Build – Use cycle (B-U)
- Evaluate – Use cycle (E-U)

The main activity cycle relation of the research community to the design research practice is to its sub-practice theorize. Theories from the knowledge base can be selected in the theorize sub-practice and furnished to build and evaluate in the T-B and T-E cycles described above (section 3.4). Theories from the knowledge base can be used as basis for developing new theories in theorize or used for theoretical grounding of developed theories [7], [21].

The abstracted result from design research/theorize is in figure 3 expressed as design theory. It is far from always that DR scholars codify their abstract results as explicit design theories according to well-known design theory templates [18], [19]. However, proper DR should abstract results in terms of prescriptions or design principles that may be useful for other design endeavours. Even if not all abstracted results from DR can be seen as full-blown design theories, they should at least contain design-theoretical fragments, like e.g. desirable properties of artefacts, principles and prescriptions for design processes.

The DR contribution to general practice is design-theoretical knowledge. This includes knowledge about artefact properties that are deemed valuable for use-situations. This may also include knowledge about appropriate procedures to conduct development of proposed artefacts. Design research requires knowledge about general practical needs. This is background knowledge that is considered valuable to all three DR practices. Therefore this activity cycle is defined as design research - general practice. In order to create an artefact solution that is not limited to studied local practices, it is important to be aware of needs that relate to the problem class situation [27]. It is not only in the build practice that it is valuable to be knowledgeable about general practical needs and problems. The artefact evaluation can also take into account general demands on the artefact solution. Theorizing should apply to abstracted/general problems, needs and artefact properties.

Through activity cycles, the practice of local use is related to build and evaluate. The build practice delivers an artefact to use. This is partially based on local practical needs, which include problems, goals, opportunities and other relevant practical knowledge. Directly observable use effects and communicated use-experiences may be fed back to build practice for revised design. In-depth studies of artefact use and different effects will be conducted through the evaluate practice. The evaluate practice studies artefact use-situations in different ways. In figure 3 this is called arrangements for capture and evaluation. There will be some intervention into local use practices by actors conducting evaluation. There may be some arranged observations. Questions can be posed to artefact users in different ways and there might be other ways of capturing data. The local use-situation will be exposed to the evaluative practice as a data source arranged according to the stated objectives of the evaluation and the design research endeavour. As described above (section 3.4), artefact evaluations should be used as basis for revised design (in the build practice) and for theory development and for empirical grounding of theories (in the theorize practice). The artefact evaluations can also be a basis for the local use-situations. Think of a situation where the evaluation does not give rise to any artefact redesign. The artefact evaluation can still be used to improve the use-situation. This can be characterised as an improvement of an artefact-given use. The intervention of a new artefact (from the build practice) implies an improvement of the local work situation. It is the artefact in itself that is a basis for improvement. An artefact evaluation can improve the local practice through evaluative knowledge about artefact use.

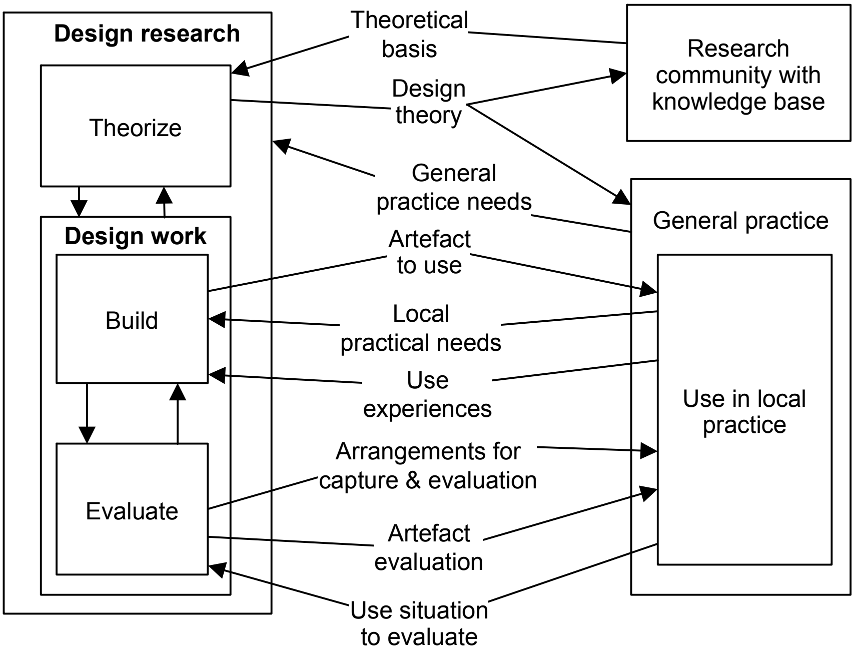


Fig. 3. Activity cycles of design research (focus on external cycles)

3.6 Multi-functionality of Practices

The pragmatic starting-point for this study has been the view that practices are *functional* in relation to each other. This also means that practices are *multi-functional*. For example, the theorize practice produces theories that should be valuable as guidance for the DR practices of build and evaluate, be a proper addition to the knowledge base of the IS research community and also a valuable contribution to general practice in activities of procurement, development and use. The designed artefact is of course primarily aimed for use in local practices. It should, however also be a basis for evaluation and theorizing. The artefact evaluation is also multi-functional. Evaluations can be a modifying basis for redesign of artefacts and they may also have a justificatory role for the conducted design. Evaluation plays a pivotal part in theorizing since it contributes with adapted and generated empirical data. It may also support an adaptation of artefact use in local practices.

It is also important to note the *amalgamation of input* in the sub-practices. For example, the build practice will blend different kinds of input (local practice needs, general practice needs, theoretical guidance of diverse kinds, use experiences and different types of evaluations) in the generation of an artefact.

4 Conclusions

After the explicit introduction of design research as an important research approach in IS, through the landmarks of [1], [2], and [3], there has been an abundance of papers attempting to conceptualise design research or parts of it. These contributions have been important since the traditional explanatory research approach has influenced our thinking to such an extent that it has been hard to imagine other ways of conducting science. This paper has also contributed with an attempt to conceptualise design research. Why yet one more? Do we need any more conceptualisations? Is it not time to say that it suffices?

The presented DR conceptualisations show great diversity even though some convergence is discernible. This diversity, fragmentation and sometimes confusion calls for an elaboration of the conceptual foundations for conducting design research within information systems. The missing theoretical dimension in the seminal work of [3] is probably a major reason for the inadequacies of several of the subsequent conceptual works. The need to integrate theorizing into DR has been acknowledged by several scholars and has also been an impetus for this paper.

This paper tries to take an explicit pragmatist stand in elaborating DR. It has investigated activities and process descriptions of DR and through this investigation it has pointed out three main sub-practices of design research and how these are related; the practices of theorize, build and evaluate. It has also identified three external practices/communities related to DR: research community, general practice and local use practice. DR relations with these external practices have been analysed and described.

The relations between the practices have been described as activity cycles following [11]. The three cycles in the Hevner framework [11] has been expanded to six activity cycles which have been described and depicted in models:

- Theorize – Build cycle
- Theorize – Evaluate cycle
- Build – Evaluate cycle
- Theorize – Research community cycle
- Design research – General practice cycle
- Build – Use cycle
- Evaluate – Use cycle

In the Hevner framework [11], the activity cycle between design research and the knowledge base (research community) is called rigor cycle. However, there must of course be rigor inside design research and its internal cycles. Rigor is rather something that is created through a proper combined execution of the different activity cycles, both internal and external cycles.

The research presented here has been conceptual. Although not explicitly referred to, due to the stated scope and aim of the paper, the author's extensive experience of DR has had a certain influence on the content of this paper. In future research the presented conceptualisation needs to be more sharply applied and related to concrete examples of design research as empirical sources.

References

1. Nunamaker, J., Chen, M., Purdin, T.: Systems development in information systems research. Journal of Management Information Systems 7(3), 89–106 (1991)
2. March, S.T., Smith, G.F.: Design and natural science research in information technology. Decision Support Systems 15(4), 251–266 (1995)
3. Hevner, A.R., March, S.T., Park, J., Ram, S.: Design science in information systems research. MIS Quarterly 28(1), 75–115 (2004)
4. Peffers, K., Tuunanen, T., Rothenberger, M.A., Chatterjee, S.: A design science research methodology for information systems research. Journal of Management Information Systems 24(3), 45–77 (2007)
5. Sein, M., Henfridsson, O., Purao, S., Rossi, M., Lindgren, R.: Action design research. MIS Quarterly 35(1), 37–56 (2011)
6. Offerman, P., Levina, O., Schönherr, M., Bub, U.: Outline of a Design Science Research Process. In: DESRIST 2009 Proceedings, Malvern (2009)
7. Kuechler, B., Vaishnavi, V.: A framework for theory development in design science research: Multiple Perspectives. Journal of AIS 13(6), 395–423 (2012)
8. Sonnenberg, C., vom Brocke, J.: Evaluation patterns for design science research artefacts. In: Helfert, M., Donnellan, B. (eds.) EDSS 2011. CCIS, vol. 286, pp. 71–83. Springer, Heidelberg (2012)
9. Niehaves, B.: On epistemological diversity in design science – new vistas for a design-oriented IS research? In: Proceedings of the Twenty-Eighth International Conference on Information Systems, Montreal (2007)
10. Carlsson, S.: Design science research in information systems: A critical realist approach. In: Hevner, A., Chatterjee, S. (eds.) Design Research in Information Systems: Theory and Practice. Springer, New York (2010)
11. Hevner, A.R.: A three cycle view of design science research. Scandinavian Journal of Information Systems 19(2), 87–92 (2007)
12. Lee, A., Nickerson, J.: Theory as a case of design: Lessons for design from the philosophy of science. In: Proc. of the 43rd Hawaii International Conference on System Sciences (2010)
13. Goldkuhl, G.: Pragmatism vs. interpretivism in qualitative information systems research. European Journal of Information Systems 21(2), 135–146 (2012)
14. Goldkuhl, G.: Design research in search for a paradigm: Pragmatism is the answer. In: Helfert, M., Donnellan, B. (eds.) EDSS 2011. CCIS, vol. 286, pp. 84–95. Springer, Heidelberg (2012)
15. Hovorka, D.: Design science research: A call for a pragmatic perspective. In: Proceedings of SIGPrag Workshop, Sprouts Working Papers on Information Systems (2009)
16. Levy, M., Hirschheim, R.: Removing the positivist straight jacket from information systems design science research. In: ECIS 2012 Proceedings (2012)

17. Dewey, J.: Logic: The theory of inquiry. Henry Holt, New York (1938)
18. Walls, J.G., Widmeyer, G.R., El Sawy, O.A.: Building an information systems design theory for vigilant EIS. Information Systems Research 3(1), 36–59 (1992)
19. Gregor, S., Jones, D.: The anatomy of a design theory. Journal of AIS 8(5), 312–335 (2007)
20. Baskerville, R.: What design science is not. European Journal of Information Systems 17, 441–443 (2008)
21. Goldkuhl, G., Lind, M.: A multi-grounded design research process. In: Winter, R., Zhao, J.L., Aier, S. (eds.) DESRIST 2010. LNCS, vol. 6105, pp. 45–60. Springer, Heidelberg (2010)
22. Venable, J., Pries-Heje, J., Baskerville, R.: A comprehensive framework for evaluation in design science research. In: Peffers, K., Rothenberger, M., Kuechler, B. (eds.) DESRIST 2012. LNCS, vol. 7286, pp. 423–438. Springer, Heidelberg (2012)
23. Peffers, K., Rothenberger, M., Tuunanen, T., Vaezi, R.: Design science research evaluation. In: Peffers, K., Rothenberger, M., Kuechler, B. (eds.) DESRIST 2012. LNCS, vol. 7286, pp. 398–410. Springer, Heidelberg (2012)
24. Iivari, J., Venable, J.: Action research and design science research – Seemingly similar but decisively dissimilar. In: Proceedings of ECIS 2009, Verona (2009)
25. Winter, R.: Design science research in Europe. European Journal of Information Systems 17, 470–475 (2008)
26. Lee, J.S., Pries-Heje, J., Baskerville, R.: Theorizing in Design Science Research. In: Jain, H., Sinha, A.P., Vitharana, P. (eds.) DESRIST 2011. LNCS, vol. 6629, pp. 1–16. Springer, Heidelberg (2011)
27. Wieringa, R.: Design science as nested problem solving. In: DESRIST 2009 Proceedings, Malvern (2009)
28. Baskerville, R., Pries-Heje, J.: Explanatory Design Theory. Business & Information Systems Engineering 5, 271–282 (2010)
29. Venable, J.: The role of theory and theorising in design science research. In: Proc. of DESRIST 2006, Claremont (2006)
30. Goldkuhl, G.: The research practice of practice research: theorizing and situational inquiry. Systems, Signs & Actions 5(1), 7–29 (2011)
31. Davern, M., Parkes, A.: Incommensurability in design science: which comes first - theory or artefact? In: Hart, D., Gregor, S. (eds.) Information Systems Foundations: The Role of Design Science. ANU E Press, Canberra (2008)
32. Fischer, C., Gregor, S., Aier, S.: Forms of discovery for design knowledge. In: ECIS 2012 Proceedings (2012)
33. Sacks, H.: Lectures on conversation. Blackwell, Oxford (1992)
34. Cole, R., Purao, S., Rossi, M., Sein, M.: Being Proactive: Where Action Research meets Design Research. In: Proceedings of the Twenty-Sixth International Conference on Information Systems, Las Vegas, pp. 325–336 (2005)
35. Schatzki, T.R.: Introduction: Practice theory. In: Schatzki, T.R., Knorr Cetina, K., von Savigny, E. (eds.) The Practice Turn in Contemporary Theory. Routledge, London (2001)
36. Goldkuhl, G., Röstlinger, A.: Context in Focus: Transaction and Infrastructure in Workpractices. In: Proceedings of the 4th Intl Conference on Action in Language, Organisations and Information Systems, Borås (2006)

Solution Prototype: A Composed Artifact as Innovation Carrier

Arkın Efeoğlu[1,2], Charles Møller[2], and Michel Sérié[1]

[1] SAP Deutschland AG & Co.KG, Service Innovation, Walldorf, Germany
[2] Center for Industrial Production, Aalborg University, Aalborg, Denmark
arkin.efeoglu@sap.com

Abstract. This paper outlines an artifact building and evaluation proposal. Design Science Research (DSR) studies usually consider encapsulated artifact that have relationships with other artifacts. The solution prototype as a composed artifact demands for a more comprehensive consideration in its systematic environment. The solution prototype that is composed from blending product and service prototype has particular impacts on the dualism of DSR's "Build" and "Evaluate". Since the mix between product and service prototyping can be varied, there is a demand for a more agile and iterative framework. Van de Ven's research framework seems to fit this purpose. Van de Ven allows for an iterative research approach to problem solving with flexible starting point. The research activity is the result between the iteration of two dimensions. This framework focuses on the natural evaluation, particularly on ex-ante validation. A correlation between Hevner's and Van de Vens framework is analyzed, and finally the proposal is presented.

Keywords: Prototype, Solution Prototype, Product Prototype, Service Prototype, Artifact, Business Model Innovation, Business Process Innovation, Design Science Research, Build, Evaluate, Diamond Model.

1 Introduction

Design Science Research (DSR) applied to Enterprise Information Systems (EIS) deals with a consensus-oriented research paradigm compared to the more traditional behavioral research methods. While behavioral science concentrates on the development and justification of theories that rather describe, explain or predict existing observations in a certain research field. DSR focuses on the construction and evaluation of artifacts. The framework in which the research is conducted is an excerpt from reality. As a precondition, the problem character must be rooted in reality. The orientation towards the solution of the problem reflects the constitutional characteristic of DSR in EIS [23], [18], [6].

Enterprise Information System related research pursue goal of knowledge and design. In many cases knowledge is the initial point for designing the respective construction of artifacts [39]. The construction of artifacts in design science research serves the purpose to explain a poorly understood real world problem [18]. Artifacts that have been built as components for problem solving can be categorized into models, methods, constructs and instantiations [23].

M. Helfert and B. Donnellan (Eds.): EDSS 2012, CCIS 388, pp. 61–75, 2013.
© Springer International Publishing Switzerland 2013

There have been analysis and discussions regarding the applicability and acceptance of design-oriented research why applied science took its time until adoption of this research method. Some reasons for this denial attitude were the conservativeness against the research method itself. It has been mentioned that alternative philosophy of science has not been accepted by researcher, other than the one that has been applied by the criticizing researcher. The rigor, particularly regarding the application of scientific standards where questioned. There has been the accusation that design science is rather a "consulting masquerading as research". Additionally the lacking generality and abstraction of context-dependent design science was criticized as well [1]. Since then design science has been increasingly formalized to provide the researchers with a foundational framework for their design-oriented research. One formalization is also Van de Vens framework that allows a more iterative and agile approach. Before Van de Vens framework is introduced the dichotomy of the design cycle of classic Design Science Research is addressed.

2 The Dichotomy of "Build" and "Evaluate"

March and Smith [23] propose to differentiate between the four research activities "Build" "Evaluate", "Theorize" and "Justify". The "Build" phase relates to the construction of artifacts while the "Evaluate" phase deals with the definition of evaluation criteria that are checked against the artifact. "Theorize" and "Justify" are the attempts to develop explanations and discoveries that proof or disproof a certain artifact's suitability under certain circumstances. Rossi and Sein [30] have a similar separation of research activities with an increased demand for a higher focus on the research gap. "Identify a need", "Build", "Evaluate", "Learn" and "Theorize" are at the center of this research activities. Vom Brocke and Buddendick [39] also relate to the "Identify" phase as the initiation point for knowledge and discovery. The phases "Build", "Document", "Select", "Evaluate" and "Communicate" complete Vom Brocke and Buddendick's phased approach.

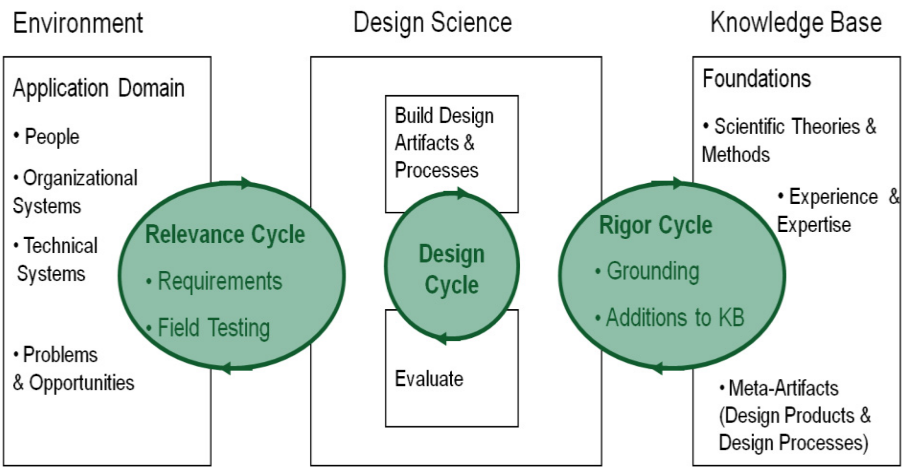


Fig. 1. Hevner's Three Cycle View on Design Science Research [17]

The dualism of “Build” and “Evaluate” is remarkable and at the core of the design science [17], [18], [39], [23], [30]. Even more centrally is the role of the artifact. As the artifact is the object in design science research that is built and then verified. According to Hevner et al. [18], an artifact can be constructs, models, methods and instantiations. An EIS prototype can range from an abstraction and representation to a working or semi-working implemented module or part of bigger implemented software. Hence a prototype is clearly categorized as an artifact [18]. The prototype can be part of an organization, a policy or a work practice which can also considered as an artifact. The prototype has therefore interrelationships with other artifacts in a systematic environment to interact with and be part of [13]. As a blending of product and service prototype the solution prototype as a composed artifact requires a more comprehensive consideration. As the sum of the solution prototype’s elements is greater than standalone, the innovation capabilities are also expected to be higher as well. The wrong mix of product and service can mislead the innovation capabilities that the solution prototype is designed for. Before the presumed research framework can be analyzed that seems to be ideal, the solution prototype’s context in innovation management need to be better understood.

3 Context of EIS-Based Solution Prototypes in Innovation Management

Prototyping is rooted in Engineering, just like Design Science Research, [18]. The environment for which the prototype is designed is important because there is also the academic void rooted that needs to be researched.

Prototyping has major impacts in the development of a new product, service, environment, or experience. There are other major impacts on organizational setup like the business processes that run or entire new business models that emerge from the validity of the prototype.

Prototypes have the advantage of building a common understanding among the involved individuals avoiding long-during discussions, extensive analysis or building hypothesis in abstract terms. Major strength of prototyping is the enablement of organizational thinking through action. Thinks that can’t be thought through right from the beginning can be easier observed during the creation of a prototype. A faster learning can be achieved and iteratively improved or re-thought from a practical and academic perspective. Failing early and often with small and low-impact failures are rather positive. Things become more tangible in early stages. Prototypes implicitly encourage new behaviors, relieving individuals of the responsibilities to consciously change their habits [38].

Prototypes as artifacts are particularly suitable as they are derived from reality. The research method must take into account how various user groups respond. Technologically sophisticated consumers are likely the prospects for new product, service or solution innovation. It is also likely that the same user group is more demanding as they deeper engage with the final product or software solution. Usually they expect a more compelling experience with the product, service or solution. The innovation researchers' recognition towards an increased value of an early and high level user engagement with a company's novel product has increased with the past two decades [35], [37].

Prototypes can be distinguished according to its designed consumption. Since evaluation can be done against the prototype as an artifact and knowledge is developable, it can also serve to answer the research questions. According to Kordon and Luqi [15] a "…prototype is an executable model of a system that accurately reflects a chosen subset of its properties, such as display formats, computed results or response time". Prototypes can be created with less effort than it takes for creating an implementation for operational use. There is no expectation that the prototype provides all of the required functions. However the attributes that address the research question is key for implementation. Hence, the prototype is a simplification of the final solution leading in faster and easier development of the artifact [15]. The demand that this this design science research has against the prototype is going beyond a functional prototype. There is the expectation to sensibilize a user's emotional experience that is given by the prototype as well [4], [3].

There is a direct link between the type of innovation and the type of prototype. While academia distinguishes types of prototypes by their attributes, disposability and reuse such as throwaway prototypes [16] the discussion in this context is rather about the extensiveness and use in business context.

As a conclusion, prototypes are very early tangible predecessors of innovative new products, services or solutions. Since there is the distinction in innovation management between product, service and solution innovation, there must also be a distinction of the prototypes depending on the purpose they meet in innovativeness. While product innovation with the respective product prototype (i.e. enterprise software product, such as CRM system) seems to be more obvious, the service prototype as part of service innovation should be further discussed, particularly solution innovation must be further elaborated. A suggestion for the reflection of the prototype types is shown below.

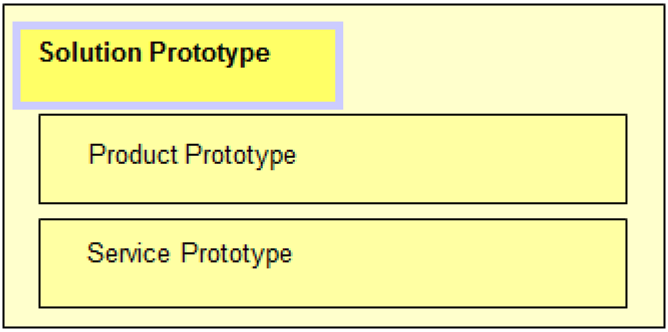


Fig. 2. Classification of Prototype Types

The two prototype types, namely product and service prototype serve as basis prototype and innovation elements to solve all other innovation disciplines.

While software product itself can be used in the process of developing innovative physical goods, the discussion in this paper is rather focused on software and service prototyping as an innovative product itself. The software product or the software related service itself is considered the innovation.

Services are by nature less or not at all tangible and cannot be stocked in the sense of goods movement. Services can be consumed solely or along with a product. [9]. For many years, service innovation wasn't taken serious as an innovation discipline. Some of the reasons for the lack of rigorous attention are the perceived low value of services by consumers compared to tangible value of industrial goods [33]. This is surprising considering that the United States as leading global economic power generates 80% of its GDP with services [5]. Today the most valuable western companies are in services. Service Prototypes as part of service innovation must go beyond an improvement in the service prototype. There must be the novelty and specialty to the prototype that clearly distinguishes it from existing services and adds new economic and experienced value to the end user. These innovative services can be processes, performances, or experiences that the service provider offers for the benefit of the service consumer, usually requiring some kind of special competencies, such as capabilities and knowledge, granting temporary access to resources, such as the people, information and technology .

A fairly new and recently defined discipline is solution innovation. Initial thoughts in the context of EIS can be traced back to 2000 [32]. In 2004 solution innovation further evolved with respect to ASP (Application Service Provisioning). This is simply expressed the predecessor of EIS-based cloud computing with a rental business model [22]. Businesses have been demanding for end-to-end business solutions that can entirely transform their business model with information systems. Companies increasingly shifted from pure product vendors to solution vendors and therefore have now to think more holistically. Accordingly their innovation processes have to adapt as well keeping in line with EIS available. New solutions that are innovative need to combine product, services and organization capabilities [32]. Hence, solution innovation comprises of product and services innovation. Such a solution prototype can comprise of one or more product prototypes (i.e.: logical integration of several and heterogeneous enterprise information systems such as ERP, CRM, cloud or mobile solution).

Early business process related initiatives such as business process reengineering were driven by business and information systems [44]. It has been understood that business can only improve, renovate or re-design their business process to a certain degree taking only organizational aspects into account. In the early nineties the term process innovation was introduced first by Davenport, who claimed that more radical changes to business are required thinking in increasingly global dimensions. The hypothesis is that only the combination of radical business process redesign along with the support of information technology can induce real business process innovation [14]. One example for such a business process innovation is the supply chain area. After multiple iteration of intra-organizational process optimization, many companies started to target on the business interface with their strategic partners and supplier to optimize at these ends. Vendor Managed Inventory was such a process innovation that has been possible with a completely new process design and the utilization of enterprise information systems. These systems could help optimize the data that was generated at the inter-organizational interface between two manufacturing companies in near real-time [19]. While Business Process Innovation is still a prevalent topic for companies in re-orienting, redefining themselves, this innovation dimension focuses very much on process cost, process flexibility, time and quality [14]. But companies today are seeking for additional revenue streams beyond new sales channels, new markets and new products. The more recent trend is in business model innovation for those companies having seen the capabilities of contemporary information technologies. The more radical the change and hence the business process innovation is, the less dependent and more dominant this process becomes over time. These type of evolved business process innovations have the characteristics to turn into a business model (innovation). For instance the App Store of Apple Inc. turned from a technology for app installation to a multi-billion app sales platform for smartphones.

Business Model Innovation today, without the utilization of enterprise information systems is inconceivable, because the speed of change in business is heavily impacted by information technology. There is the consensus that at the core of a business model there is the value proposition to the customer, the profit and revenue formula, the key resources and innovative processes enabled by information technology [20], [8], [25], [24]. Prototypes can be one means to validate the innovation discipline. The service prototype, for instance, can help to validate the degree of the service innovation. The object of an artifact is always either a product prototype (i.e.: physical or intangible product such as software) or a service prototype or the meaningful composition in a solution prototype. Future published papers in this series of research, will be focused on user-led innovation cycles. More specific the research will be in "*User-led innovation cycles – Value of design thinking oriented solution prototyping in*". Both, business process innovation and business model innovation offer the right space for this research.

4 Classification of EIS-Prototypes in the Design Cycle of Build and Evaluate

The impact and complexity of solution prototypes as artifacts must be understood to understand the prototypes innovation capabilities. The solution prototypes evaluation should only be allowed in an ex-ante way analyzed in its systematic environment. This requires a broader freedom to iterate between the design and validation with an agile fit for purpose. Not only does the Van de Ven framework focus stronger on the iteration but also obliges on a stronger collaboration between academia and practitioners.

4.1 Building the Prototype

The prototype as the central artifact is supposed to serve as a prescriptive means to solve the research problem that has its roots in reality. As part of the design science research that is used, the theory being built will theorize "how to do something" [10].

The theory that is developed will naturally explain why artifacts should have certain characteristics [36]. It appears logical that the product, service or solution prototype will not be the only artifacts that will be created and used for answering the research question. The prototypes are the instantiated form of an artifact [11]. The other elementary forms of artifacts, namely construct, model and method will also be subject for theory building [18]. Constructs which are abstracted concepts will enable the derivation for theorizing and the trans-situational use. According to March and Smith [23] the "conceptualizations are extremely important in both natural and design science. They define the terms used when describing and thinking about tasks". Models are situated between the problem space and solution space helping to explore the effects of design decisions and the impact of changes in the real world. Design Thinking as an innovation method for practitioners has the same approach [4]. Models use constructs to depict a real world situation, hence the design problem and solution space [13]. The value of methods is in giving directions on how to solve problems or respectively how to search for the solution space. Such methods can be logically expressed mathematically or less structured in textual descriptions or best practices. Failing IT projects have their roots in underestimating the complexity and its fit for purpose. Thus there is a particular importance on the prototype as an instantiation with its problem solving characteristics. The instantiation demonstrates the feasibility and its suitability in a real world environment [18].

The design practice with the prototypes as artifacts will produce situational design knowledge. The iteration between design knowledge consumption and production will be improving the situational knowledge gathered through the artifact or respectively the prototype [12]. Situational design knowledge is used for empirical grounding of abstract design knowledge and abstract design knowledge is used for theoretical grounding of situational results [11]. The justification of design knowledge means to investigate and present warrants for such knowledge. Researchers identified that a strong collaboration with practitioners is required to acknowledge the theoretical part [27], [28].

4.2 Evaluating the Prototype

The central artifact has to be applicable and useful in reality for practitioners (relevant) and at the same time contributing to the EIS knowledge base (rigorous). It must undergo a strong evaluation process to qualify for both rigor and relevance. Evaluation has been a topic both in general IS research and in design science research. In the general IS literature, evaluation is generally regarded from one of two perspectives. In the ex-ante perspective, candidate systems or technologies are evaluated before they are chosen and acquired or implemented. In the ex-post perspective, a chosen system or technology is evaluated after it is acquired or implemented [21]. The prototype as a potential predecessor or conceptual excerpt of a final product will focus on the ex-ante perspective.

The prototype will be evaluated in its real environment (i.e.: within the company that it has been tailored for). Venable [42] calls this natural evaluation, because the artifact's performance can be measured under realistic circumstances [42]. This evaluation method offers the possibility to evaluate the prototype in use, by real or potential users, solving a business challenge. Due to its reference to reality, the natural evaluation has to be placed after the design practice outcome [41]. Compared to artificial evaluation which includes laboratory experiments, field experiments, simulations, criteria-based analysis, theoretical arguments and mathematical proofs [40] the natural evaluation leverages methods like case studies, field studies, surveys, ethnography, phenomenology, hermeneutic methods, and action research. This is most appropriate because naturalistic evaluation covers all of the complexity of human practice in real organizations [41]. The central means being used for this research will be the application of real use cases or case studies from within the context of business process innovation or business model innovation.

4.3 Application of the Van de Ven Framework as Part of DSR

Further grounding on the design cycle of Hevner [18] with particular focus on "Build" and "Evaluate" the iterative characteristics of the Van de Vens Engagement Framework suits for building the solution prototype as artifact that complies with the core idea of DSR. The Van de Ven framework concentrates on the instantiation of an artifact (prototype) as understood by Hevner [18] and March & Smith [23]. Van de Vens Framework [28] as an action and design science engagement framework [34] bridges the debate on how to address rigor and relevance in EIS [2], [14].

Design Thinking (DT) as an increasingly practiced innovation method will be used to build the prototype with end users. DT will support conducting the field research or creating the case study. The discoveries made during the "Build" phase with Design Thinking will be evaluated against the Van de Ven framework to create the related design knowledge. The design knowledge serves than as input for the re-iteration of the "Build" phase when the artifact (prototype) is altered, refined or further developed to increasingly fit the problem space as solution.

Van de Vens framework [28] is appropriate because the researcher applying this framework is not accepted as observer only. In addition, the researcher is asked to engage with experts from academia as well as practice. Hence this framework is highly collaborative, expecting the involvement of experts in each phase of the research. Van de Ven [28] argues that the more complex the problem or the more comprehensive the research question is, the more collaboration between researchers and practitioners are required from different disciplines. The knowledge created in science and practice are different but they do not stand in opposition to each other or even substitute for each other. Van de Ven sees both knowledge gains as complementary to one another [28]. Knowledge in practice is rather experience oriented and situational whereas scientific knowledge seeks for generalization and trans-situational use of knowledge by deriving formal logic with causal relationships. The less context-dependent a theory is, the more general and the more profound it is [43].

Van de Ven's [28] engagement framework that is also known as the diamond model considers the four dimensions of Model, Solution, Reality and Theory. These four dimensions are interrelated with each other, helping to specify the research activities. The more often the iteration is around a dimension and the stronger the relationship between two dimensions, the more concrete is the definition and specification of the research activity. In Van de Ven's diamond model [28] the research activities such as Research Design, Theory Building, Problem Solving and Problem Formulation conclude from the interaction of two dimensions [28].

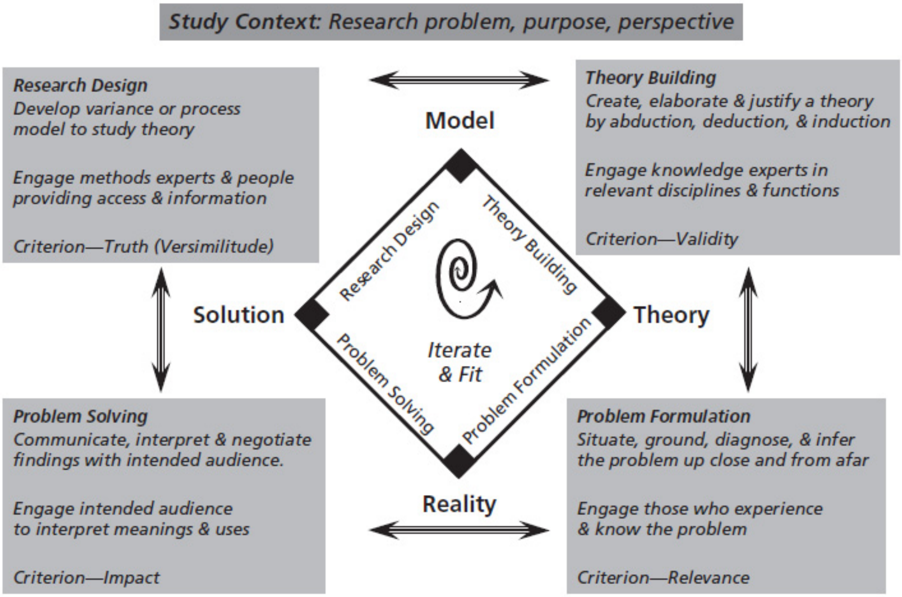


Fig. 3. Engaged Scholarship diamond model [28]

There is no requirement to start with one particular dimension or research activity. In my research there will be particular notice on the problem formulation to ensure the design-orientation. Many researchers tend to be solution-minded, rather than problem-minded underestimating the problem formulation and rushing through it. The goal is to avoid missing undetected problem spaces or opportunities that could be overseen [29].

The diamond model of Van de Ven complies with Design Science Research as the focus is in actionable and design-oriented research. If Hevner's Three Cycle View on Design Science Research can be considered as one of the central DSR frameworks than the Environment dimension can be compared to the Reality dimension of Van de Ven's diamond model. Similarly, the Design Science dimension with "Build" and "Evaluate" can be compared to the Solution and Model dimensions. Finally, the knowledge base is then the counterpart of the Theory dimension where situational and trans-situation knowledge is stored that has been created earlier or through the design cycle [28], [18].

Referring specifically to the role of the solution prototype as instantiation artifact, the following table indicates with which means the artifact can be built and evaluated.

Table 1. Composed Artifact building and evaluation proposal

	Goal	Build Output	Evaluation Metrics	Methodology
Constructs	Identify the relevant business challenges in process and business models	concepts that fit the use case	fit for purpose; measures from concepts alike	literature, interviews, ideation, cross-industry transferrable concepts
Methods	use innovative methods	siutational model	novelty degree; degree of innovation, business measure; performance indicators	literature, ideation (Design Thinking); best practice
Models	non-executable idea collection	instantiable (prototypable) models, with given feasibility, disaribilty and viability	performance indicators; value proposition to end user	ideation (Design Thinking); best practice; corporate idea pool
Instantiations	Create a refined prototype that suits the problem and allows theory building	Low-fidelity of high-fidelity Prototype	trans-situation use in familiar situations; performance indicators, value proposition to end user; industry thought leadership feedback;	ideation (Design Thinking), feedback, measures, solution-fit questioning academic mehtods that worked, best practice, community-driven measures

5 Conclusion

The solution prototype as a composed artifact requires special attention during its build and evaluate phase, because solutions in general offer the option to vary the degree of mix between product and service. The solution innovation degree can be strongly impacted by the solution prototype's mix between product and service prototype. An iterative approach of developing the artifact is preferred to find the right mix. The Van de Ven framework allows iterating in each dimension and doesn't impose on with which dimension to start with. The research related activities are emerging from the iterations of two dimensions. This kind of action-oriented and agile research method seems to suit best for composed artifacts. The ex-ante validation requirement of the Van de Ven framework for the solution prototype has the advantage of giving a glimpse on the ex-post validation of an roll-out capable solution for real world usage. It is expected that the value of the solution prototype is greater than the sum of its elements (product & service prototype). This article prepares for a series of research papers that will cope with "User-led innovation cycle – value of design thinking oriented solution prototyping".

6 Design of Case Studies: Insight-Driven Development of Solution Prototypes That Bridge Research and Business Challenge

Orlikowski and Iacono [26] refer to the IT artifact as the "core subject matter" in the EIS research.

Having understood the importance of this particular instantiation from an artifact there are some questions that only can be answered if dedicated prototypes are developed for each major question that relates to a challenge in reality. In this research it is intended to find answers to the following primary questions:

Primary Questions:

1. Do low-fidelity prototypes deliver a higher value than the high-fidelity prototypes
   →Study 1
   Value of Prototypes with respect to viability, feasibility and desirability

2. Is the prototype the breaking point for a potential business model innovation or business process innovation?
   →Study 2
   How can the tangibility of solution prototypes within design thinking process with focus on viability influence the decision making stronger than traditional business cases or business plans in a business model innovation (not traditional or existing business models).
   Is the empirical
3. Is the implicit knowledge that is inherent to the prototype more valuable than the research or look-up related knowledge base?
   →Study 3
   Is the prototype carrying more knowledge than the derived theory in the knowledge base

4. What are challenges that arise with composition of product and service prototypes into a solution prototype?
   →Study 4
   How do the design thinking phases for solution innovations need to be constructed assuming that application of design thinking for service innovation is different than product innovation.

Prototype Study 1

- Create a low-fidelity and high-fidelity EIS prototype in parallel with two split but similar teams. Explore the innovation capabilities for a business model and evaluate the value in terms of the business model innovation's feasibility, desirability and particularly business viability.
- Document preparational work of team members, behavior in certain situations, relying to work experiences, evaluate against internal and external (end-user) feedback
- Define comparable measures for evaluating the low-fidelity (LF) and high-fidelity (HF) prototype
- Discuss the strategic, operational and economic value with stakeholders
- Discuss the LF vs. HF prototype desirability with end-users for realization and personal use
- Reiterate, refine the prototype or start over completely from scratch towards the research problems and business challenge's solution while documenting knowledge

Prototype Study 2

- Research and Interview decision makers rationale based on solution prototype creation and availability
- Design solution prototypes with the intention to influence stakeholder's decision making on a business model
- Determine hard and soft factors (measures) related to the solution prototype for decision making in business model innovation
- Understand the time that is required by stakeholders for decision making based on data from the prototype in order approve the realization of a new business model that is innovative
- Build in design elements and features into the prototype that can lead to refusal or acceptance of solution prototype
- Evaluate the single team members' identification with the solution prototype and the buy-in to a business model after prototype generation
- Reiterate, refine the prototype or start over completely from scratch towards the research problems and business challenge's solution while documenting knowledge

Prototype Study 3

- Determine knowledge carrier characteristics of a prototype
- Analyze the comprehension capability, knowledge transfer and the learning-by-doing value of a prototype
- Analysis knowledge translation from prototype to theory and storage in knowledge base
- Research whether a prototype with fewer features can carry more knowledge compared to a feature-rich solution prototype
- Compare knowledge carrier characteristics of EIS-prototypes with prototypes not related to software.
- Reiterate, refine the prototype or start over completely from scratch towards the research problems and business challenge's solution while documenting knowledge

Prototype Study 4

- Co-develop a product and a service prototype that complement each other in a business process or business model innovation
- Understand the linkage between product and service prototype
- Analyze the design thinking process for adaption for a composed artifact, particularly solution prototype
- Understand the solution prototype's ideation power at the interface between product and service prototype
- Compare results with cross-industry results

- Evaluate trans-situational use and fit for similar challenges from reality in other domains or industries
- Reiterate, refine the prototype or start over completely from scratch towards the research problems and business challenge's solution while documenting knowledge

All four prototype studies will be researched in further academic papers and will be leveraging a unified structure with at least for comparability reasons:

1. Purpose, Scope and Contribution
2. Functionality
3. Current State, Evaluation, Future research

References

1. Baskerville, R., Wood-Harper, A.T.: A Critical Perspective on Action Research as a Method for Information Systems Research. Journal of Information Technology 11, 235–246 (1996)
2. Benbasat, I., Zmud, R.W.: Empirical Research in Information Systems: The Practice of Relevance. MIS Quarterly 23(1) (1999)
3. Buchenau, M., Suri, J.F.: Experience Prototyping. In: DIS 2000, Brooklyn, NY, pp. 424–433. ACM (2000)
4. Brown, T.: Design Thinking. Harvard Business Review 86(6), 84–92 (2008)
5. Bitner, M., Ostrom, A.L., Morgan, F.N.: Service Blueprinting: A Practical Technique For Service Innovation. California Management Review 50(3), 66–94 (2008)
6. Cao, J., Crews, J.M., Lin, M., Deokar, A., Burgoon, J.K., Nunamaker Jr., J.F.: Interactions between System Evaluation and Theory Testing - A Demonstration of the Power of a Multi-faceted Approach to Information Systems Research. Journal of Management Information Systems 22(6), 207–235 (2006)
7. CACM Journal (Communications of the ACM), Special Issue on "Service Science," July 2006; Journal of Retailing Special Issue on "Service Excellence," 83(1) (2007)
8. Chesbrough, H.: Business Model Innovation: Opportunities and Barriers. Long Range Planning 43(2-3), 354–363 (2010)
9. Fagerberg, J., Mowery, D.C., Nelson, R.: The Oxford Handbook of Innovation. Oxford University Press, s.l. (2006)
10. Gregor, S.: The Nature of Theory in Information Systems. MIS Quarterly 30(3), 611–642 (2006)
11. Goldkuhl, G.: Design theories in information systems-a need for multi-grounding. Journal of Information Technology Theory and Application (JITTA) 6(2), 7 (2004)
12. Goldkuhl, G., Lind, M.: A multi-grounded design research process. Global Perspectives on Design Science Research, 45–60 (2010)
13. Simon, H.A.: The Sciences of the Artificial, 3rd edn. MIT Press, Cambridge (1996)
14. Davenport, T.H.: Process innovation: reengineering work through information technology. Harvard Business School Press, Boston (1993)
15. Kordon, F.: Luqi; An introduction to rapid system prototyping. IEEE Transactions on Software Engineering 28(9), 817–821 (2002)
16. Gordon, V.S., Bieman, J.M.: Rapid prototyping: lessons learned. IEEE Software 12(1), 85–95 (1995)

17. Hevner, A.R.: Design Research - Rigorous and Relevant, Keynote. In: 15th European Conference on Information Systems (ECIS 2007), St. Gallen (2007)
18. Hevner, A.R., March, S.T., Park, J., Ram, S.: Design Science in Information Systems Research. MIS Quarterly 28(1), 75–105 (2004)
19. Holmström, J.: Business process innovation in the supply chain – a case study of implementing vendor managed inventory. European Journal of Purchasing & Supply Management 4(2-3), 127–131 (1998) ISSN 0969-7012, 10.1016/S0969-7012(97)00028-2
20. Johnson, M.W., Christensen, C.M., Kagermann, H.: Reinventing Your Business Model. Harvard Business Review, 51–59 (December 2008)
21. Klecun, E., Cornford, T.: A Critical Approach to Evaluation. European Journal of IS, 229–243 (2005)
22. Kakabadse, N.K., Kakabadse, A., Ahmed Pervaiz, K., Alexander, K.: The ASP phenomenon: an example of solution innovation that liberates organization from technology or captures it? European Journal of Innovation Management 7(2), 113–127 (2004)
23. March, S.T., Smith, G.: Design and Natural Science Research on Information Technology. Decision Support Systems 15(4), 251–266 (1995)
24. Osterwalder, A., Pigneur, Y.: Business model generation: a handbook for visionaries, game changers, and challengers. Wiley, Hoboken (2010)
25. Osterwalder, A.: The Business Model Ontology - a proposition in a design science approach. Dissertation, University of Lausanne, Switzerland: 15 (2004)
26. Orlikowski, W.J., Iacono, C.S.: Research Commentary: Desperately Seeking the IT' in IT Research—A Call to Theorizing the IT Artifact. Information Systems Research 12(2), 121–134 (2001)
27. Ostrowski, Ł.: Detailed Design Science Research and its Impact on the Quality of Design Artefact. In: Helfert, M., Donnellan, B. (eds.) EDSS 2011. CCIS, vol. 286, pp. 60–70. Springer, Heidelberg (2012)
28. Van de Ven, A.H.: Engaged Scholarship: A Guide for Organizational and Social Research. Oxford University Press, New York (2007)
29. Volkema, R.J.: Problem Formulation in Planning and Design. Management Science 29(6), 639–652 (1983)
30. Rossi, M., Sein, M.K.: Design Research Workshop - A Proactive Research Approach (2003), http://tiesrv.hkkk.fi/iris26/presentation/workshop_designRes.pdf (February 1, 2004)
31. Davenport, T.H., Markus, M.L.: Rigor Vs. Relevance Revisited: Response to Benbasat and Zmud. MIS Quarterly 23(1) (1999)
32. Shepherd, C., Ahmed, P.K.: From product innovation to solutions innovation: a new paradigm for competitive advantage. European Journal of Innovation Management 3(2), 100–106 (2000)
33. Vargo, S.L., Lusch, R.F.: Evolving to a New Dominant Logic for Marketing. Journal of Marketing 68, 1–17 (2004)
34. Mathiassen, L.: Collaborative Practice Research. Information Technology & People 15(4), 321–345 (2002)
35. Schrage, M.: Serious Play: How the World's Best Companies Simulate to Innovate. Harvard Business School Press, Boston (1999)
36. Pries-Heje, J., Baskerville, R.: Designing Organizational Change in IT: A Theory Nexus. In: First International Conference on Design Science Research in Information Systems and Technology, Claremont, California (2006)
37. von Hippel, E.: The Sources of Innovation. Oxford University Press, New York (1988)

38. Coughlan, P., Fulton-Suri, J., Canales, K.: Prototypes as (design) tools for behavioral and organizational change. Journal of Applied Behavioral Science 43, 122–134 (2007)
39. vom Brocke, J., Buddendick, C.: Reusable Conceptual Models – Requirements Based on the Design Science Research Paradigm. In: Proceedings of the 1st International Conference on Design Science Research in Information Systems and Technology (DESRIST 2006), Claremont, pp. 576–604 (2006)
40. Pries-Heje, J., Baskerville, R., Venable, J.: Strategies for Design Science Research Evaluation. Paper read at 16th European Conference on Information Systems (2008)
41. Sun, Y., Kantor, P.B.: Cross-Evaluation: A New Model for Information System Evaluation. Journal of the American Society for Information Science and Technology, 614–628 (2006)
42. Venable, J.: A Framework for Design Science Research Activities. Paper read at The 2006 Information Resource Management Association Conference, Washington DC (2006)
43. Aram, J.D., Salipante Jr., P.F.: Bridging Scholarship in Management: Epistemological ReXections. British Journal of Management 14, 189–205 (2003)
44. Davenport, T.H., Stoddard, D.B.: Reengineering: Business Change of Mythic Proportions? MIS Quarterly 18(2), 121–127 (1994)

Process for Assessment Data Quality in Complex Service Oriented Architectures Using Design Science Approach

Łukasz Ostrowski, Plamen Petkov, and Markus Helfert

School of Computing, Dublin City University, Glasnevin, Dublin 9, Ireland
{lostrowski,ppetkov,markus.helfert}@computing.dcu.ie

Abstract. Service oriented composition is a prospective approach, which enables flexible and loose composition of applications whereas data is an integral part of service. Our research examines various perspectives of data quality in the flexible service oriented environment. In this paper we present a process that would assess data within service oriented environment based on business rules. By analysing service data against the rules we are able to identify problems in service composition and execution. Moreover taking into account the Quality of Service (QoS) we can provide an approximate location of the error. The process is developed following design science, and in this paper we underline the literature review perspective.

Keywords: Design Science Methodology, SoA, Systematic Literature Review.

1 Introduction

Service oriented architectures (SoA) are a promising approach that offers the business a flexible and agile way of integration new services and thus improve the dynamic of the business process. Owing to the SoA key principles such as reusability, interoperability, and standardization, enterprises can benefit in many ways [1] – reducing the costs of operation and maintenance [2], less time for applying new services [3], more agile service management [4]. According to recent surveys, conducted by different independent organizations [5] among 400 IT professionals, the primary driver to undertake SoA project was cost savings as well as short time to response the market needs. The tasks of developing completely new applications, making certain adaptors for legacy systems, or rewriting present applications are now outdated [6]. Principally boosted by Web services connectivity, service-oriented architectures are now considered the preferred way to designing an information system.

However, in more complex architectures orchestrating the services can be difficult to handle [7]. It could be really challenging to managing such architectures without having the awareness of the data, processes and events running within the enterprise environment. To support the process of orchestrating, as well as development and evolving progress, a data monitoring techniques must be integrated [8]. These methods, of course, must comply with business requirements, in order to achieve adequate surveillance results. In other words, management tools and manners are

M. Helfert and B. Donnellan (Eds.): EDSS 2012, CCIS 388, pp. 76–87, 2013.
© Springer International Publishing Switzerland 2013

inadequate without using an appropriate monitoring. Thus why, crucial assistant for proficient and effective deployment and operation of an SOA-based net-centric system is a comprehensive monitoring capability. Nevertheless, present monitoring solutions fall short [9] with respect to such systems because they do not hold the capabilities to effectively detect poor data - inconsistent or inaccurate data and so to provide comprehensive shared situational perception. Hence, considering the facts we have pointed above, the need of assessing process is more than obvious.

In this paper we propose a holistic approach to assess data within service oriented environment. We achieved that by developing a business process for data evaluation that will follow business rules approach. Moreover, in order to assure that our process is applicable and feasible we followed design science research methodology [10]. Ultimately our process aims to guide enterprises when considering developing and assessment tool to their business.

The rest of this paper is structured as follows: In the next section, we describe our employed research methodology - the process oriented reference model [11] derived from design science paradigm. Section 3 briefly presents how we executed a literature review part of the methodology to build our process for detecting data quality issues in the service oriented way. Then, we elaborate on each step that comprises our process for assessment data quality in SoA. Finally, section 4 will conclude our work by summarizing the major points and providing some directions for our future work.

2 Design Science

Design science focuses on creations of artificial systems. It addresses research through the *building* and *evaluation* of artefacts designed to meet identified business needs [10]. Design is proposed as a research strategy to gain knowledge and understanding about the object under construction. Artefacts are understood as entities that have some separate existence [12]. In our research, the artefact is the process of assessment data within the service oriented environment. To build the artefact we referred to the process-oriented reference model that was introduced as a part of the design science methodology for researchers aiming at process construction. Fig. 1 illustrates the model in the design science settings.

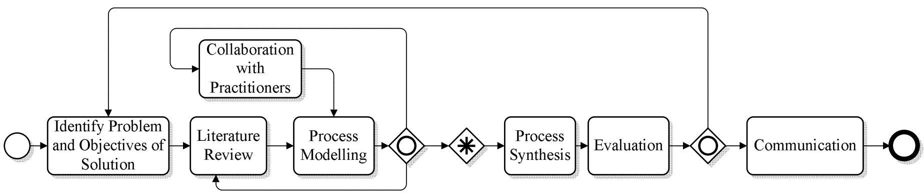


Fig. 1. Overview of the Process Oriented Reference Model in Design Science Research [11]

While we acknowledge this iterative nature of the activities involved, the model will be discussed as a linear sequence of steps to keep the description straightforward.

2.1 Problem and Objectives of Solution

In the first phase of the research process, a problem is defined. It has to show a practical relevance or might be of relevance once showed [13]. Problem identification defines the specific research problem, justifies the value of a solution, and should be in the domain of information systems research, either from the academia or industry. The problem definition will be used to develop an artefact that can effectively provide a solution. Objectives for such a solution refer to the knowledge of what is possible and feasible. The objectives can be quantitative, such as terms in which a desirable solution would be better than current ones, or qualitative, such as a description of how a new artefact is expected to support solutions to problems not hitherto addressed [14].

2.2 Literature Review

A methodological review of past literature is a crucial endeavour for any research work [15]. The need to uncover what is already known in the body of knowledge prior to initiating any research study should not be underestimated [16]. Thus the process oriented reference model starts with conducting a systematic literature review. It splits this activity into a broad and advanced search.

The broad search concentrates on finding research relevant materials. The main focus is put on reading abstracts, conclusions, prefaces, and references of the found materials in order to collect as much potential leads to relevant information as possible. The rigor of the systematic search process is one factor that distinguishes this approach from others. It is iterative and benefits from identification of existing systematic reviews, assessing the volume of potentially relevant materials, and using various combinations of search terms derived from the initial scope.

The advanced search focuses on analysing and assessing the actual relevance of the found materials. Main and secondary objectives along with the exclusion criteria from the initial scope are intended to identify those materials that provide direct evidence about solution for the domain. In order to reduce the likelihood of bias, these criteria may be refined during the search process. Moreover, the quality of those materials is assessed. The aims are to weight the importance of individual information when retrieving particular activities for the desired process; to lead the interpretation of findings and determine the strengths of results; to provide recommendations for further research.

The ultimate goal of the literature review is to identify activities from the found materials. Each activity should be accompanied with a meaningful description and rational of selection. It is a good routine to keep the search for materials transparent and replicable as far as possible. Thus, the research should be documented in sufficient way that the readers are able to access the thoroughness of the search. Once activities from the literature are determined, they are shaped into a process.

2.3 Process Modelling

The process oriented reference model distinguishes two main modelling activities. First one structures the found activities into knowledge base. This provides semantic constraints of concepts, once either literature review or collaboration with practitioners finished gathering information. This is achieved thanks to ontology engineering. The second activity is to model a solution based on the knowledge base. It uses Business Process Modelling Notation [17].

Ontology Engineering. It gives researchers the design rationale of a knowledge base, kernel conceptualization of the world of interest, semantic constraints of concepts together with sophisticated theories and technologies enabling accumulation of knowledge which is dispensable for knowledge processing in the real world [18].

The concept of ontology engineering process involves defining terms in the domain and relations among them; defining concepts in the domain (classes); arranging the concepts in a hierarchy (subclass-superclass hierarchy); defining attributes and properties of classes and constraints on their values; defining individuals and filling in property values. Ontology engineering approach reflects the structure of the world; is often about structure of concepts; actual physical representation is not an issue [11].

Business Process Modelling Notation (BPMN). Having structured the knowledge base, the design science researcher constructs the process model in this phase. The most desirable modelling technique for business processes should be expressive and formal enough but easily understandable also by final users and not only by domain experts faced out. At the present, the state-of-the-art in the field is represented by BPMN [19].

This phase starts with an overall picture of the business and continues by analysing each of the functional areas of interest. This analysis can be carried out to specify the level of detail required. The technique exploits a method called top-down expansion to conduct the analysis in a targeted way. The result is a series of diagrams that represent the investigated process. The process comprises one or more business process diagrams. Initially a context diagram is drawn, which is a simple representation of the entire domain under investigation. This is followed by a level 1 diagram; which provides an overview of the major functional areas of the domain. The level 1 diagram identifies the major business processes at a high level and gives rise to a corresponding level 2, which is its decomposition. The decomposition of the process can then be continued – through level 3, 4 and so on. However it is very unusual to go beyond a level 3 diagram.

2.4 Collaboration with Practitioners

The aim of this phase is similar to the literature review with the exception that practitioners' expertise is used as the source of information for the process. Practitioners are recruited and selected based upon predefined characteristics such as relevant work experience on the domain under investigation. If practitioners do not have congruent or conflicting interests, a focus group can be formed. A focus group enables participants to react to other group members and to produce common activities for the process that might have not been uncovered in individual interviews. It provides a reasonably rich data set and importantly it allows the researcher to draw conclusions about contrasts or similarities in the collective opinions across various focus groups as well as the depth of dissenting opinions within a particular focus group [20].

2.5 Process Synthesis

Different process models may use terms and concepts with subtly different meanings, thus the first step in this phase is to combine all ontologies and produce a mutual knowledge base. This knowledge base is to integrate models comprising natural language results and conclusions. The most generic process of the investigated domain is obtained by tabulating in a manner consistent with the domain problem. Tables are structured to highlight similarities and differences between models. This is achieved by employing meta-ethnography synthesis which put together written interpretive accounts [21], where mere integration would not be appropriate. In determining how process models are related, a list of themes or tables to display concepts across all process models is created. This puts on ease comparing the themes and concepts from model 1 with model 2, and the synthesis of these two models with model 3, and so on, beginning from the list of themes created above, but keeping an open mind for emerging ones. As the comparison continues, the initial broad categories of themes are gradually refined by merging and collapsing. While this approach is pragmatic, and assisted in the synthesis of many disparate process models, it is possible that this prior categorizing had some effect on the results of the synthesis, and may also have constrained the emergence of new categories [22].

There is a general acceptance that the synthesis process cannot be reduced to mechanistic tasks, and may, in practice, be difficult to replicate. Differences in synthesis approaches may also be due to differences in the extent to which included studies report second order interpretations and in the number of process models included in the synthesis.

2.6 Evaluation

Once the process reaches a sufficient state, its evaluation can be started. Evaluation delivers evidence that a solution developed in design science research achieves the purpose for which it was designed.

Researchers identified a number of methods that can be used for evaluation of design science artefacts. Hevner [23] proposed five classes of evaluation methods: (1) Observational methods include case study and field study. (2) Analytical methods include static analysis, architecture analysis, optimization, and dynamic analysis. (3) Experimental methods include controlled experiment and simulation. (4) Testing methods include functional testing and structural testing. (5) Descriptive methods include informed argument and scenarios. Selection of the appropriate method depends on the purpose of the process stated in the objectives. Two goals should be achieved here. One is to demonstrate that the process feasibly works to achieve its purpose in at least one context. The second considers how well the process supports a solution to the problem.

2.7 Communication

At the end of the evaluation phase, results are summarised and published. This could be in form of a PhD thesis, journal or conference article [24]. Researchers should publish individual results and intermediate data to gain early feedback on the research results. The focus should be on specific contexts for individual or organizational gain. That is, the importance of the problem and the novelty and effectiveness of the solution offered by the artefact should be explicitly underlined.

3 Process for Assessment Data Quality in SoA

The following process describes the application of the process oriented reference model in design science research. First we outline our research motivation and questions. Then, we present the execution of the systematic literature review and derived results. Since, the aim of this paper is to underline the literature review perspective to our research problem, all insights and activities identified by practitioners has been detached.

In the period of 8 months, we have investigated the data quality in the context of SoA in academic and professional literature. We found that in complex architectures orchestrating the services can be difficult to handle without having awareness of the data. Hence we set as the research objective a discovering a process that will facilitate detecting poor information. In order to build our process we need to determine two important questions: (1) How we define poor data in SoA? and (2) How we detect viral data within Service oriented Environment? Following the process oriented reference model, a systematic literature review was conducted. Fig. 2 illustrates our approach to the systematic literature selection. Closer attention was paid to publications, special issues, and specialist conferences that explicitly emphasized on the keywords ‘define’ and ‘detect’ poor data.

Looking from informational quality point of view the term ‘detecting’ is comprised in the term ‘defining’. This suggests that before poor data to be detected it must be *defined* first. Researchers identified a number of definitions about data quality [25] [26]. Some of them are different and other share common idea [27]. Poor data, on the other hand, can be dafined as contradiction of quality data. Based on the statements and references above about qualitative data we define poor data. Form information technology point of view, poor data can be any data which does not satisfiy business requirements of its intend and thus fail to deliver enterprices expected results.

Concerning methods for *detecting* bad quality data in information systems, literature identifies few approaches. Some of them include data ontology analysis [28] [29], other direct database analyses by using trust tables [9], third rely on applying business rules [30] [31]. In our process we took into account business rule approach because it allows assessing data more objectively than the other approaches since it allows the business ultimately to define the data in the context it is used. As one of the definitions of data quality states: "Business ultimately defines data quality". Unlike other methods for evaluation data quality, effectiveness of business rules method depends on the quality of the business rules. In that way data quality is linear function of the business rule quality.

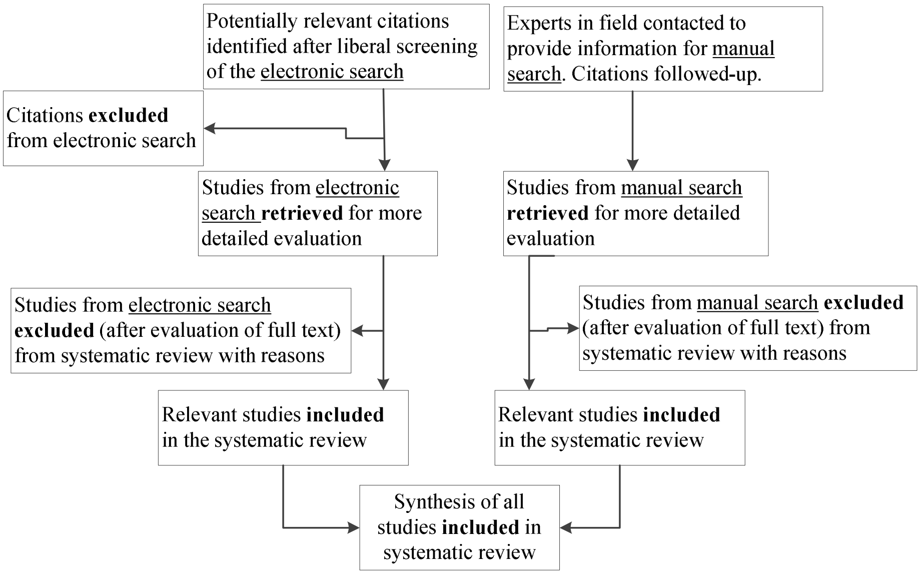


Fig. 2. Flow Diagram of study selection procedure [32]

We derived our process by following the general perception of data quality management (DQM) [33]. Our literature findings identified four main stages in data quality cycle - Quality Assessment, Quality Design, Quality Transformation and Quality monitoring - followed by seven sub stages: Capturing Metadata, Profile Data, Data rules, Data flow, Process Flow, Execution and Monitoring stages. As it can be perceived from Fig. 3, this process is too generalized and thus does not provide us with specifics way to detect quality issues and particularly in service oriented architectures. However, it delivers a valuable direction of the overall process of data assessment and monitoring. Hence, we followed this process paying particular attention to the core elements of detecting poor information within service environment.

Taking into account data quality management, business rule approach, standards and specifications such as (Business Process Execution Language) BPEL, (Web Service Description Language) WSDL and Simple Object Assess Protocol (SOAP) involved in SoA, we delivered the process for assessment data quality in SoA. The following section presents the process.

Fig. 3. Data Quality Life Cycle [33]

3.1 Process for Assessment Data in SoA

The process of assessing monitoring data consists of three main stages – preparation, execution and analysing stages, each of which is composed of few steps or sub-stages. Preparation phase comprises the following steps: capturing Business Process (BP); extracting the services and variables involved into the chosen business process or sub-process; constructing business rules based on the services and variables involved in the chosen BP; mapping and saving created rules into repository; Next phase of the process is the execution stage preceded by pre execution stage. In pre-execution stage existing rules are checked for validity. Then execution stage involves following steps: reading the rules defined in preparation stage; building and sending SOAP requests to services through ESB; waiting for response from the services and constructing result; saving the results in log file. After execution stage is completed, the analysing stage is followed. It involves reading the generated log file, analysing the results and creating summary report activities.

The BPMN Diagram on Fig. 4 depicts overview of the process of data quality assessment in service composed environment. In the next few headings we describe each phase in more detail.

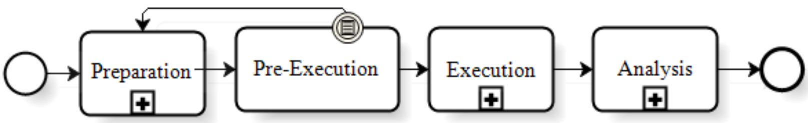


Fig. 4. Data Quality Assessment Process in SoA

Preparation Stage. Preparation stage is the phase where the quality is described DQM describes this stage as Quality Design (see Fig. 3). In this stage business person chooses a process and defines a business rule or set of rules that apply to it. In this way, an enterprise explicitly defines the quality of the information it needs and uses.

Selecting a BP Process. In this step a business process or sub-process is selected by an authorized person. The process of selection could be executed in two ways – (see figure 4) by picking business process from visual software tool for modelling and executing business processes(point and click) or (2) selecting the BP by using start and end point variables through BP engine console.

Extracting BPEL Variables. In extraction phase, the business process chosen from previous step will undergo series of analysis. Ultimately specific meta-data (data about the process) will be obtained and temporary stored. This meta-data will include 'service name', 'operation', 'input' and 'output' variables. For the purpose of the extraction, BPEL file containing the prescription of the selected process will be open for examination. The process of analysing will consist of scanning the file and searching for BPML attributes that correspond to the metadata that need to be collected.

Building the Monitoring Rules. The actual construction of the rules is done by business body – architect or administrator. The metadata stored temporary form BP reader in extraction stage then is referred to WSDL repository and files containing the relevant variables are opened Then a list of services along with their data/read functions is presented to the user. Next the business administrator/architect composes the rules using Business rule approach.

Mapping the Rules with Processes and Storing Them into Repository. The composed rules are stored in an external repository. In order to maintain their execution in loosely coupled way, we introduce a holistic way to store the rules into XML files. Hence we propose suitable XML template which stores process ID and all Rule correlations. The implementation of the XML template will be omitted due to the scope of the paper.

Execution Stage. Execution stage is the phase where the defined by business quality applies to the data. More specifically, in our case, the defined quality is done by following the process of composing monitoring rules described in previous paragraphs. Next few paragraphs describe how this rules are execution in the service oriented way.

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

Reading Rules from Repository and Building SOAP Enquiries. As contradistinction with other SQL – based approaches, our will allow information to be assessed without having direct access to a particular physical data source. This suggests that in this phase we use the existing SOA infrastructure and more particularly the SOAP standard, the Enterprise Service Bus (ESB) and most importantly the Message Router block. The Message Router block is usually part of the SoA Business Process Engine (BPE). Its job is to dispatch accordingly every SOAP message to different services.

Executing and Waiting for the Results. After the all SOAP enquiries have been dispatched, the services generate outputs in accordance with their get operations input parameter. The generated results are being collected by Message Aggregator block which, in its part, is also part of the Business Process Engine. Message Aggregator's role is to collect all the outputs generated form the services and the compare them with the expected results. The key part in this stage of the process is checking if any of the services that have been inquired by the Message Router block is involved in execution of some Business Process. This is very important since service that has been used to produce data can be, in the same time, inquired to provide data. This may cause so called 'dead lock' or in other words inaccurate detection. We avoid that by mapping the rule with the process. (See Preparation stage) In this way the services involved into monitoring rule and the process ID stored are compared.

Generating Log. Generating is the output phase of the Execution Stage. The final result provided by the Message Aggregator is stored in specific problem log file. Although there are approaches to specify log formats, current approaches such as the Common Log Format and Combined Log Format of W3C are not sufficient for our approach, as they are not directly able to represent the required information. Therefore, we propose a practical oriented log file which will contain information such as id, name, instance, address etc. about the services caused the mismatching as well as violated value and other related rules involved. The presentation of the log file will be intentionally excluded in order to narrow the scope of the paper.

Analysing Stage. Analysing stage can be referred to the quality monitoring stage in DQM it our case analysing stage involves generating to a problem-cause reports in accordance to the user preference – e.g. generating report with the names of the 'faulty services' or 'number of the mismatched rules'. In any way, in order to generate such reports a services' log must be read first. Ultimately the analysing stage aims to evaluate the whole process of detecting viral data.

4 Conclusions

In this paper we presented a process that assesses data within service oriented environment based on business rules. Apart from other well-known methods for directly extracting or integrating business rules form and into business process, our approach differs in the way by providing the business bodies with a holistic solution that will aid them with building rules which will serve as data quality arbiter. The approach uses BPEL language to extract services names and operation and then with backend by WSDL library offers a list of operations that aid the business architect witch composition of the rules.

Following design science approach, activities for the process were derived from academic and professional literature. The next step is to construct the process based on the SoA and data quality practitioners' contribution, and synthesize both outcomes. This would give us the consolidated process for assessing data quality in service oriented environment. Additionally, we aim to provide a way to deliver monitoring rules by analysing the regular business rules that are stored into business rule repository. Our ambitions include that we apply the consolidated process to a real case scenario.

The process also demonstrates a successful application of the process–oriented reference model in design science research. We thus started with identification of the objective of the research, then carried out systematic literature review and engaged practitioners to build the process in BPMN. The meta-ethnography synthesis of the processes gathered from various literatures was presented in this paper. This paper itself constitutes the communication phase of the methodology.

Acknowledgments. This work was supported by the Irish Research Council for Science, Engineering and Technology under the Enterprise Partnership Scheme.

References

1. Bell, E., Michael, M.: Service-oriented architecture: a planning and implementation guide for business and technology. Wiley, Hoboken (2006)
2. Krafzig, D., Banke, K.: Enterprise SOA, service-oriented architecture best practices. Prentice Hall, Upper Saddle River (2004)
3. O'Brien, L., Merson, P., Bass, L.: Quality Attributes for Service-Oriented Architectures. In: SDSOA 2007 Proceedings of the International Workshop on Systems Development in SOA Environments, Washington, DC, USA, p. 3 (2007)
4. Papazoglou, M., van den Heuvel, W.-J.: Service oriented architectures: approaches, technologies, pp. 389–415 (2007)
5. Austvold, E.: Service-Oriented Architectures: Survey on Deployment and Plans for the Future. ARM Research Report (2006)
6. Brne, B., Kling, J., McCarty, D.: The value of applying the data quality analysis pattern in SOA. IBM (April 17, 2008)
7. Petkov, P.: Data oriented challenges of service architectures a data quality perspective. In: CompSysTech, New York, NY, pp. 163–170 (2012)
8. Kazhamiakin, R., Metzger, A., Pistore, M.: Towards Correctness Assurance in Adaptive Service-Based Applications. In: Mähönen, P., Pohl, K., Priol, T. (eds.) ServiceWave 2008. LNCS, vol. 5377, pp. 25–37. Springer, Heidelberg (2008)
9. Fishman, N.: Viral Data in SOA: An Enterprise Pandemic. IBM Press, New York City (2009)
10. Hevner, A.R., March, S.T., Park, J.: Design Research in Information Systems Research. MIS Quarterly (2004)
11. Ostrowski, L., Helfert, M.: Reference Model in Design Science Research to Gather and Model Information. In: 18th Americas Conference on Information Systems, Seattle (2012)
12. Goldkuhl, G.: Design Theories in Information Systems – A Need for Multi-Grounding. Journal of Information Technology and Application 6(2), 59–72 (2004)

13. Benbasat, I., Zmud, R.W.: Empirical Research in Information Systems-The Practice of Relevance. MIS Quarterly 23(1), 3–36 (1999)
14. Peffers, K., Tuunanen, T., Rothenberger, M.: A Design Science Research Methodology. Journal of Management Information Systems 24(3), 45–77 (2007)
15. Webster, J., Watson, R.T.: Analyzing the past to prepare for the future: Writing a literature review. MIS Quarterly 26(2), 13–23 (2002)
16. Hart, C.: Doing a Literature Review. Releasing the Social Science Imagination. Sage Publications, London (1999)
17. OMG: Business Process Modelling Notation, `http://www.omg.org/spec/BPMN/2.0/` (accessed March 2012)
18. Mizoguchi, R.: Tutorial on Ontological Engineering. New Generation Computing 21(4), 363–384 (2003)
19. Chinosi, M., Trombetta, A.: BPMN: An introduction to the standard. Computer Standards & Interfaces 34(1), 123–134 (2012)
20. Gibbs, A.: Focus Groups. Social Research Update, 19 (1997)
21. Noblit, G.W., Hare, R.D.: Meta-Ethnography: Synthesizing Qualitative Studies. Sage Publications (1988)
22. Atkins, S., Lewin, S., Smith, H., Engel, M., Fretheim, A., Volmink, J.: Conducting a Meta-Ethnogrpahy of Qualitative Literature: Lessons Learnt. BMC Medical Research Methodology 8(21) (2008)
23. Hevner, A.R., March, S.T., Park, J., Ram, S.: Design Science in Information Systems Research. MIS Quarterly 28, 75–106 (2004)
24. Offermann, P., Levina, O., Schönherr, M., Bub, U.: Outline of a Design Science Research Process. In: Design Science Research in Information Systems and Technology, Malvern (2009)
25. Gewirtz, P.: Oh I Know It When I See It 105. Yale Law Journal (1996)
26. Redman, T.: Data Quality: The field guide. Digital Press, Woburn (2001)
27. English, L.: Improving Data Warehouse and Business Information Quality: Methods of reducing Costs and Increasing Profits. John Wiley & Sons, Inc., New York (1999)
28. Henriksson, R.M., Kauppinen, T.: An Ontology-Driven Approach for Spatial Data Quality Evaluation. In: The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, vol. 34 (2007)
29. Frank, A.U.: Data Quality Ontology: An Ontology for Imperfect Knowledge. In: Winter, S., Duckham, M., Kulik, L., Kuipers, B. (eds.) COSIT 2007. LNCS, vol. 4736, pp. 406–420. Springer, Heidelberg (2007)
30. Wang, R.: A product perspective on total data quality management. Communications of the ACM 41(2), 58–65 (1998)
31. Vasilecas, O., Normantas, K.: Deriving business rules from the models of existing information systems. In: 12th International Conference on Computer Systems and Technologies, New York, NY, pp. 95–100 (2011)
32. Egan, M., Petticrew, M., Ogilvie, D., Hamilton, V.: The Health and Social Impacts of Opening New Road. Protocol for Systematic Review. University of Glasgow, Glasgow (2001)
33. Oracle, I.: Understanding Data Quality Management. In: Oracle® Warehouse Builder User's Guide. Oracle Inc. (2008)

In-Place Translation in Information Systems Development

Jonas Sjöström[1,2] and Madelen Hermelin[1]

[1] Department of Informatics and Media, Uppsala University
{jonas.sjostrom,madelen.hermelin}@im.uu.se
[2] Department of Public Health and Caring Sciences, Uppsala University

Abstract. Computers have been considered and appropriated for natural language translation since the late 1940's. Since the commercialization of the Internet in the early 1990's, the role of computers to support translation work has expanded. The idea of 'crowd sourcing', i.e. engaging website visitors or community members, has been appropriated to enable 'crowd translation' or 'community translation' of multi-lingual web sites. In this paper, we present Babbler - a novel concept for community translation. The concept is described. A proof-of-concept (software implementation) was built and put into use in an information systems development project. The concept and the software were evaluated through log analysis and interviews with translators. We demonstrate various qualities of the concept and its implementation, including its effectiveness, efficiency, reliability, workflow, implementability and performance. Improvement opportunities, implications for future research and implications for practice are discussed.

Keywords: Translation, Crowdsourcing, Information Systems Design, Design Science Research.

1 Introduction

Multi-language web sites are now prevalent. Designing for multiple languages introduces specific challenges to information systems development (ISD). The software *per se* needs to be designed to support multiple languages. Further – and perhaps more importantly – there is a need to address the translation of text into multiple languages. Translation is an important activity both during the initial design of software, as well as in software maintenance and continued design.

In 1949, Warren Weaver first introduced the idea of using computers for natural language translation. Weaver proposed the use of statistical techniques that were commonly adopted in communication theory [15]. More recently, in the World Wide Web context, practitioners and scholars have developed several novel translation practices and translation tools. While machine translation is still being explored, computers are also employed as collaboration tools for human translation, i.e. 'crowdsourcing' for translation purposes. Different incentives are put into play to promote people to contribute to translations.

M. Helfert and B. Donnellan (Eds.): EDSS 2012, CCIS 388, pp. 88–98, 2013.
© Springer International Publishing Switzerland 2013

Community translation – or collaborative translation – is somewhat similar to 'crowd' translation through its interest in engaging groups of stakeholders to actively contributing to the translation process. The difference, arguably, is the delineation Crowd implies that we seek to engage as many people as possibly, in order to harvest the 'wisdom of the crowd' [6]. Crowd translation approaches are gaining attention in industry [12]. Community translation, on the other hand, seeks to establish new forms of translation practices and design tools to support the collaboration process and enhance the quality of translations.

It is well known that design processes benefit from stakeholder participation [1, 7-8, 13-14]. We base this work on the idea that community translation can be used as an instrument to engage stakeholders during design. Community translation has been discussed as a general phenomenon. It is, however, not been researched as part of ISD. The aim of this work is to examine an emerging translation concept that we refer to as in-place translation, in the context of ISD. The novelty in our concept, we argue, lies in its simplicity and in its application within ISD.

We demonstrate the in-place translation concept, where it supported an ISD process the context of health care. A proof-of-concept is provided (a software implementation), and we evaluate the concept through (i) log data about the translation process and (ii) interviews with the domain experts who appropriated the software most frequently to contribute to the translation process. Based on the evaluation, we reflect about the qualities of the proposed translation concept, and discuss improvement opportunities.

2 Drawing from the Knowledge Base

Several social media sites, e.g. Twitter and Facebook, employ crowd translation techniques to engage their community to support translation. In addition, web browsers are given translating capabilities through extensions and 3rd party plug-ins, such as 'Right-click and Translate' and 'Translate selected text' plug-ins for Google Chrome. In addition, user-generated translations are extended through installable modules in content management platforms such as Drupal. We include these examples to indicate the increased interest for translation in the software industry. Another sign of the commercial interest in crowd translation is that Facebook filed an application for a patent regarding 'community translation on a social network' (US patent No. 2009/0198487 A1).

Both crowd translation and community translation are based on the premise that users are empowered to translate phrases within the application environment. Clearly, such a solution can be devised in different ways. Several solutions, such as Facebook's translation tool and the 'Right-click and translate' plugin for Google Chrome, offer the users to translate a text 'in place', i.e. do the translation in the same view where text is translated. In a translation situation, user interfaces (UIs) are typically designed to support the translator through information about the original phrase, as well as alternative translations in different languages.

We do not claim to present a comprehensive overview of related artifacts. We do, however, argue that there is an increased commercial interest and an increasing use of artifacts for crowd translation. The latest translation features in Facebook are very similar to the artifact we will present here, though they have been developed independently in parallel. The latest additions to the Facebook translation feature include 'inline translation' with a UI similar to the one we propose in this paper.

As outlined in the introduction, our main inspiration from the literature is the idea of engaging a 'community' or 'crowd' in the translation process. Another important concept is that we are interested in translation in the context of IS development. First, the approach should be beneficial since the users themselves decide how to phrase texts in the UI. The idea of incorporating business language into UI design has been advocated by IS researchers – there should be a 'match between the system and the real world' [11]. Second, empowering users to translate text 'in-place' offer them a novel type of participation in the development process. User-centeredness is often depicted as an important element in IS development [9-10, 13]. By assigning *to users* the responsibility to translate texts they are inevitably entangled in the design work. If they do not contribute, the design process halts.

In order to promote use of the translation features, we strived for usability ideals. In particular, we wanted the features to be simple and easy to learn, in order to promote the traditional usability goals effectiveness, efficiency and satisfaction [13]. It was assumed that without a simple and easy-to-learn design, the translation feature would not be used at all.

3 Method

This study is part of a larger design science research (DSR) endeavour in the research programme U-CARE at Uppsala University. In brief, DSR guidelines [5] state that the design cycle should be informed by a relevance cycle and a rigor cycle [4].

U-CARE offers a good environment for to promote relevance in research. The overarching goal of U-CARE is to promote psychosocial health among patients struck by somatic disease and their significant others, ideally at a lower cost to the benefit of individuals and society. Research is conducted in close collaboration between research groups in clinical psychology, information systems, and economics. Initial research activities are performed within the areas of paediatric oncology, adult oncology and cardiology in close collaboration with clinicians at Uppsala University Hospital. The studies are designed in close collaboration with several clinical environments and patient organizations. The design process was set up in accordance with agile values [2]. Development sprints lasted for 2–3 weeks, followed by sprint reviews where various stakeholders were exposed to the latest version of the platform. In addition, external specialists and patient groups were invited to explore the software, followed by workshops in which they provided feedback to the design team. In total, 40+ design workshops have been organized, engaging a great variety of stakeholders.

With respect to rigor, researchers from multiple disciplines have contributed to the design process. Through collaboration with psychologists and researchers in psychology, knowledge about previous software platforms and the knowledge base from psychology was factored in to the design process. IS researchers ingrained the design process with knowledge from the IS field and its sibling disciplines (primarily interaction design and software engineering). The IS input is based on a pragmatic stream of IS research, focusing social interaction through instrumental use of technology [14, 16]. The software was equipped with a logging function to enable retrospective analyses of user actions. Analysis of log data reveals how users worked with the translation tool. In addition, six interviews were conducted with frequent translators to allow for a qualitative assessment of translation work. Interview data was interpreted and categorized, rendering categories that explain respondent perceptions of qualities of the translation process. Evaluation is further elaborated upon in section 5. Essentially, we embrace rigorous evaluation methods to demonstrate the qualities of the proposed artefacts.

4 Babbler – A Translation Artifact

In this section, we present 'Babbler', a piece of software that facilitates in-context collaborative translation of web applications. Babbler was developed within the design process outlined in section 2. The conceptual solution, is ingrained with the following ideas:

1. Make translation as simple as possible (one-click to translate) in the user's current view
2. Allow for context-dependent translation as well as translation of 'global' phrases
3. In a translation situation, provide the user with relevant alternative translations
4. Any type of text element, independent of how it is embedded in the page, should be possible to make 'translatable'
5. Support translation both for full page requests and for asynchronous requests

An elementary conceptual model (Fig. 1) is sufficient to keep track of translations. Basically, a phrase key (created by the software developers) can have several translations ('babbles') provided by different users. A 'babble' is a translation of a phrase key into a particular language. When a new translation is stored for a phrase key, the old translation is marked as deleted, and the time of the deletion is stored. This model allows us to keep track of all translations for a phrase key (old and new ones), for different languages.

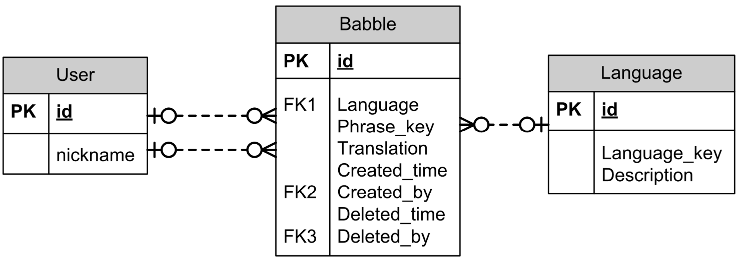


Fig. 1. Conceptual Model for Babbler

The dynamics of the translation tool (Fig. 2) is a bit more complex, due to the architecture of web pages that may require translation services in numerous situations. In abstract, there are two situations that need to be managed: Page load-translation and asynchronous translation. The latter situation is common due to the increased popularity of asynchronous web requests, i.e. scripted code on the client side that makes requests to the web server without reloading the entire web page.

Fig. 2 shows how a web browser requests a page from the web server. The web server analyses the URL to set the translation context. This mechanism is necessary to allow for situated translations (on that page) or generic translations (translating into the same result across all pages). The code that produces the view that is returned to the browser utilizes Babbler functions to translate phrases. The developers are thus required to utilize the Babbler function library when presenting any piece of information in a view, in order to ensure that the view is fully translatable. They also need to make a decision if the translation of that text should be valid only in the current page, or across pages. In addition to the page request flow, a browser may also make asynchronous requests (e.g. loading a part of a page using Ajax). Therefore, there is a simplified flow, which basically consists of a request for a translation of a particular phrase, and a response (the translation). The server, therefore, needs to store the page context in the user session state in order to properly translate asynchronous translation requests. In addition, the server keeps track of the logged in user, and the user's preferred language.

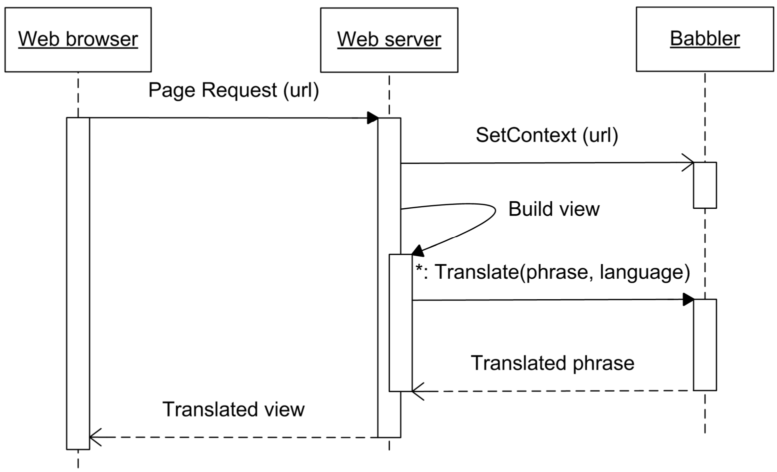


Fig. 2. Babbler translation dynamics

HTML documents may encapsulate text in different ways, e.g. in normal paragraphs and in input fields such as dropdown lists. Due to this variety, there was a need to build an application programming interface (API) that distinguished between different element types, which have different behaviour in the two translation modes (on/off). The element type 'normal' is used for regular text. The element type 'embedded' is used in embedded text elements (such as dropdown lists). In addition, a 'helper' element type was added to facilitate translation links for the embedded text elements. Fig. 3 shows how the element type in combination with the translation mode determines how a text is displayed or not, and whether or not it is translatable (through right-clicking it).

		Element type		
		Normal	Embedded	Helper
Translation state	On	Translatable	Plain text	Translatable
	Off	Plain text	Plain text	Invisible

Fig. 3. Translation states and element types

In order to make an embedded text translatable, this concept forces the developers to add two lines of code in the view page: One for the embedded element and one for the helper element.

5 Evaluation

The in-place translation was introduced to a set of users during the development process of the U-CARE portal. The translation work was not 'designed' in any way – we let the translators self-organize. Domains expert – who were also future users of the portal – were informed about the translation tool basics. Developers were instructed how to make text elements translatable by using the babbler API. Evaluation of the software implementation of the conceptual solution consisted of a log analysis (section 5.1) and interviews with the most frequent users (section 5.2).

5.1 Log Analysis

All translated phrases were stored in the database, allowing us to keep track of all translations, including the user who added it and the time it was added. We focus a set of users contributed substantially to the translation work (Table 1).

Table 1. Top 12 translators and their translation count

User	Count	Explanation
Donald	1744	Developer
Claire	226	Research coordinator
Peter	186	Used by Donald to translate participants' views.
Thomas	98	Psychologist
Paula	97	Used by Claire to translate participants' views.
Audrey	81	Research assistant
Phil	81	Used by Thomas to translate participants' views.
David	59	Developer
Pagona	55	Used by a therapist to translate participants' views.
Penelope	49	Used by a therapist to translate participants' views.
Tuula	47	Psychologist
Tony	39	Psychologist

We argue that the quick and independent adoption of the translation feature signals ease-of-learning and ease-of-use. The users started to organize themselves and took responsibility to translate the views that were most related to their specific interests in the software. Claire did translations due to her role as a coordinator between different work groups, making her responsible for the overall translation progress. Donald did the initial re-factoring of the software to support Babbler. While doing this he also added a lot of initial translations. At one point, translations from one language (*Swedish for adults*) were copied into another language (*Swedish for teens*) in order to facilitate language adaptations for each target group. The implication is that Donald's translation count was doubled. The other developer in the list, David, is not Swedish speaking, which explains his low translation count.

5.2 Interview Results

The users who contributed most to the translation work were asked two open-ended questions each about their impressions from the translation process:

- We are interested in your impressions from the translation process. What worked well, and what did not work well?
- If the translation process – the software and/or the way you work with it – should be changed, what would be the most important changes?

In total, six interviews were conducted (with users Thomas, Tony, Claire, David, Audrey and Tuula). Open-ended questions were asked in order to let the respondents' speak freely about the things they found most important. The second question was raised when the respondent had nothing more to add to the first question, to get an answer focusing improvement opportunities. The answers were categorized thematically in an inductive interpretation process, rendering four categories: (i) Effectiveness – quality of the result and the goal fulfilment, (ii) Efficiency – the amount of work required to translate, (iii) Reliability – the extent to which users could rely on the translation software, and (iv) Workflow – the collaboration quality in the translation work. Each category will be further discussed below. All the quotes were translated from Swedish into English by the authors. The authors added text in brackets.

Effectiveness. The respondents generally expressed that they could effectively translate phrases using Babbler[1]. From the interviews, we learn that the original phrase keys – created by the developers – need to be well phrased to avoid confusion among the translators. Several translators missed that they could access alternative translations, and translations in other languages.

"The original text [phrase key] can be tricky – the thing that you see before someone provided a translation. This has sometimes been incomprehensible. In those cases you don't know how to translate, but I guess the developers follow a standard we don't know." (Tony)

[1] The effectiveness of the solution is also supported by the logged translations, showing that the users managed to translate all text elements in the software.

"It can sometimes be hard to translate, you don't know the meaning of the text. Example: 'Mark as read' and 'mark as archived' – what does that mean?" (Claire)

"Sometimes you are a bit unsure if the last translation is really the best." (Thomas)

Efficiency. Several respondents brought up the efficiency of the translation process. Overall, they appear to find the translation work efficient, as indicated by the following statements:

"In general, I think that the [translation] tool worked smoothly. I haven't encountered any bugs or misunderstandings. It's a very good idea that users can translate on the fly." (Tony)

The translators also pointed out a number of efficiency problems, related to phrase key design, translation across pages, decision support, and increased automation in translation. There could be better decision support for translators, e.g. the possibility to make notes, and to better indicate the target audience for the text is (e.g. patients, therapists). Finally, machine translation techniques such as spelling correction may improve efficiency.

"You can often go to the same submenu from different places. Then you have to change [translate] every submenu separately. It is hard to find all places before you are used to it [the translation tool]." (Audrey)

"[..] You often miss translation alternatives. I use a thesaurus while translating. As usual you wish the software would work more for you, e.g. a search function for text that needs translation. It is easy to miss things, e.g. [..] when you think you translated something [but it isn't reflected across pages as one anticipated]. Maybe you would want to return to things you noted [..]. The software does not appear to have any automatic spelling correction, which would reduce simple mistakes. I also miss an undo button." (Audrey)

"Hard to say who translated. During translation, I am unsure if the translation will only be visible for a psychologist or, for instance, for health staff. It should be more explicit where the translation is visible, and for whom." (Claire)

Reliability. The translators expressed concerns regarding the reliability of the translation tool. The concerns relate to two factors: (1) *Human error* by developers when building the view pages and (2) the problems attached to software development in a *heterogeneous technical environment*[2]. While the technical problems were continually remedied during the design process, we focus on human error here. If developers do not use the Babbler API when creating or updating pages, user experiences like the ones below follow:

[2] The use of browser-side scripting is necessary to provide a good UI for translation. Nevertheless, it caused problems with incompatibilities between web browsers, special considerations for asynchronous translations, and some general troubles to solve software implementation issues.

"Everything hasn't been translatable." (Thomas)

"Perhaps it is not related to babbler, but it is a bit frustrating when you see a text in English that is not directly translatable." (Tony)

"As a user, one can be frustrated when it doesn't work. For example if it [text] is pink [red] but still not translatable, then you have to disturb the developers." (Claire)

Workflow. The respondents explicitly brought up the 'workflow' in the translation process, but there were also many cues about the need for a structured workflow. Most comments related to workflow were related to respondent uncertainty about the status and quality of the translation work.

"It is unclear who decides what translation to use when there are multiple suggestions. [..] In a way I'm happy that we didn't get any education, or that we didn't have eternal discussions about how things should be done. One could get started on the fly. [..] Maybe you should be able to vote for translation so that the most popular one wins." (Thomas)

"[..] Now we had to make a print screen and send it to the developers. [..] but maybe some solution that made it possible to highlight [..] phrases directly in the software. There is a need for better logistics. Now I couldn't notice if a word had been made translatable until I accidently checked it later." (Tony)

"[..] it feels like [the developers] have many important things to do, so you don't want to disturb. [..] we need to find a workflow for translation. Sometimes I don't know who translated. [..] Everybody can translate, different concepts are used [..]" (Claire)

6 Concluding Discussion

We have demonstrated how ideas from crowd translation can be appropriated in an ISD context. We have demonstrated that our artifact is easy-to-use, effective, and our interpretation is that it had a positive effect on user participation in the development process. Using the DSR knowledge contribution framework [3], we characterize our work as an *exaptation* of knowledge appropriated in a new context. Babbler, a novel tool to facilitate collaborative in-context translation has been presented, and assessed through (i) a log analysis that demonstrates that users have effectively used the tool for translation, and (ii) interviews with the most frequent users that were used to discuss various qualities of the tool and conditions that need be fulfilled for successful translation work.

Table 2 shows a summary of evaluation results for the proposed translation concept in a user-centred development process. Our idea was that if the conceptual solution and its corresponding software implementation are simple enough, the users would be able to use it effectively without instruction. In essence, that was the outcome of the process. However, as shown in the evaluation section, there are several opportunities to improve the effectiveness, efficiency, reliability and the workflow in the translation work. There appears to be a need for (i) a more systematic workflow to support collaboration in the translation work (practice improvements, and (ii) better decision support for translators within the software solution (software improvements).

Table 2. Summary of evaluation results

Quality	**Evaluation results**
Implementability of concept	The in-place translation concept is implementable, as shown through the proof-of-concept (the Babbler software).
Software performance	Translators do not mention performance, which indicates that software performance is sufficient. There is a need for more performance evaluation before using the software in a more transaction-intensive context.
Effectiveness	All text elements in the U-CARE portal were translated by users. However, Translators expressed uncertainty regarding the quality of translations.
Efficiency	Translators' comments indicate that the Babbler software – through its simple design - was efficient to use. There are improvement opportunities, such as better decision support, e.g. spelling correction and more visible info about alternative translations and translation scope.
Software Reliability	The software as such has reached a stable state, but the design concept is prone to human error by developers.
Workflow	The translators self-organized to solve the translation work, but translators express a need for more structured workflow and decision-making.

With regard to *practice improvements*, there is a need to mitigate the errors caused by human factors among developers. There appears to be a need to train developers to be consistent in showing phrases as babbles, and develop conventions for phrase key definitions. In addition, it makes sense to maintain a shared document with agreed-upon definitions of terms including 'global' phrase keys for developers. Further, there is a need to setup a mechanism that enables translators to report issues to developers. The final practice improvement concerns the collaboration/communication between translators. A simple but effective solution might be for translating staff to meet regularly to address translation issues and make decisions. Interestingly, one of the translators expressed that the lack of structure could also be interpreted as a positive thing due to the lack of constraints imposed on translators.

The translators provided several practical suggestions about *software improvements*. Some improvements relate to transparency. The UI should indicate whether a text is 'local' or if a translation of it will affect other pages. Further, the UI could reveal more clearly alternative translations to a phrase, as well as explicit information about the target group of the translation. Another improvement suggestion was to integrate a spelling correction mechanism to better support the translator.

Our findings show that the idea of crowd translation may prove useful in ISD. We believe that this research may be useful to other researchers interested in software process improvement and stakeholder-centric design.

Acknowledgements. This research is part of the research programme U-CARE at the Department of Public Health and Caring Sciences at Uppsala University, with substantial financial support from the Swedish Research Council (VR).

References

1. Avison, D., Wood-Harper, T.: Multiview Methodology. Blackwel Scientific Publishing, Oxford (1990)
2. Conboy, K.: Agility from first principles: Reconstructing the concept of agility in information systems development. Information Systems Research 20(3), 329–354 (2009)
3. Gregor, S., Hevner, A.R.: Positioning and Presenting Design Science Research for Maximum Impact. MIS Quarterly 37(2), 337–355 (2012)
4. Hevner, A.R.: A Three-Cycle View of Design Science Research. Scandinavian Journal of Information Systems 19(2), 87–92 (2007)
5. Hevner, A.R., March, S.T., Park, J., Ram, S.: Design science in Information Systems research. Mis Quarterly 28(1), 75–105 (2004)
6. Howe, J.: The rise of crowdsourcing. Wired Magazine 14(6) (2006)
7. Krippendorff, K.: The Semantic Turn - A new Foundation for Design. CRC Press (2006)
8. Mumford, E.: Effective requirements analysis and systems design: The ETHICS method. Macmillan, Basingstoke (1995)
9. Mumford, E.: The Ethics Approach. Communications of the ACM 36(6), 82 (1993)
10. Mumford, E.: The story of socio-technical design: reflections on its successes, failures and potential. Information Systems Journal 16(4), 317–342 (2006)
11. Nielsen, J.: Usability Engineering. New Riders Publishing, Indianapolis (1993)
12. O'Hagan, M.: Studies on translation and multilingualism Crowdsourcing translation. Linguistica Antverpiensia, New Series - Themes in Translation Studies (10), 11–23 (2011)
13. Preece, J., Rogers, Y., Sharp, H.: Interaction design: beyond human-computer interaction. John Wiley & Sons, Inc., New York (2002)
14. Sjöström, J.: Designing Information Systems. Uppsala University (2010)
15. Weaver, W.: Translation. In: Locke, W., Booth, A. (eds.) Machine Translation of Languages; Fourteen Essays. MIT Press, Cambridge (1955)
16. Ågerfalk, P.: Getting pragmatic. European Journal of Information Systems 19, 251–256 (2010)

An Exploration of Customer-Centric Cloud Service Design

Brian O'Flaherty, Simon Woodworth, Colm Thornton, and Yvonne O'Connor

Business Information Systems, University College Cork, Ireland
boflaherty@afis.ucc.ie

Abstract. Cloud computing applications and services go hand in hand, yet there is no clear mechanism for ensuring that the cloud applications are designed from a customer's perspective. This paper describes the initial design and development of a predictive analytics cloud service application, which uses historic customer data to predict the existing customers that are most likely to churn. Service blueprinting, a service innovation method, was being used as the underlying design model for developing an initial shared understanding of the required service. The Design Science paradigm can focus on the development of the IT artifact, but it can also develop an Information Systems Design Theory (ISDT) as a research outcome. This paper considers service blueprinting as kernel theory or underpinning mechanism for a Cloud Service Design Theory (CSDT), which will enable developers to prescribe designs of customer centric cloud based service applications. Using the design science paradigm an extended cloud service design theory is proposed, as an outcome of the ongoing development of this analytics platform.

Keywords: Service Blueprinting, Cloud Service Design Theory and Customer-centric.

1 Introduction

The Cloud phenomenon is herald as a disruptive concept that can change how software and associated applications and services are delivered. Much of the design effort in cloud application development has focused on technical deployment issues, such as payloads on virtual machines [1] and uniform abstract description across, service, platform and infrastructure levels [2], while there is a lack of emphasis on customer level design. This paper explores the collaborative design of a cloud application addressing the issue of design from a customer perspective; it also attempts to frame the experiences of this application development in the context of the Design Science paradigm.

However, prior to discussing this service it is paramount to provide a theoretical understanding of 'services'. To fully understand the functionality and form of a service many researchers turn to service design. Service design consists of tools, which describe the customer-centric approach in new service development. Some tools are available for mapping out the service process, such as service blueprinting or service mapping.

M. Helfert and B. Donnellan (Eds.): EDSS 2012, CCIS 388, pp. 99–111, 2013.
© Springer International Publishing Switzerland 2013

PredictX is a proposed predictive analytics service for predicting customer churn. Predictive analytics is driven by quantitative algorithms that uncover relationships and patterns from large volumes of data that can be used to predict behaviour and events [3]. Customer churn prediction aims to identify subscribers who are about to transfer their business to a competitor and is now preformed regularly in a computer assisted manner [4]. It is extensively used in mature industries with a high degree of competition, such as the Telecommunications industry [5].

This paper sets out to explore developing guidelines for Cloud-based service developers and considers the potential of theory building as an outcome of Design Science, which will be explored through further development of an analytics platform.

2 What Is a Service?

The concept of a 'service' has received a lot of attention in both the academic and practitioner domains. However, the state-of-the-art in academic research has revealed that there is a lack of a comprehensive definition of what constitutes the term 'service'. This lack of consensus on the meaning of 'service' has led to numerous definitions. It is evident from Table 1 and existing literature that most scholars consider services to consume activities, deeds or processes, and interactions [6], [7] &[8]. This is evident when reviewing the characteristics of services. Performing extensive literature reviews on the area of services, Zeithaml et al. [7] and Edgett and Parkinson [9]

Table 1. Definitions of service

Author	**Definition**
Hill [10]	"A change in condition or state of an economic entity (or thing) caused by another."
Grönroos [11]	"An activity or series of activities of a more or less intangible nature that normally, but not necessarily, take place in the interaction between the customer and service employees and/or physical resources or goods and/or systems of the service provider"
Vargo and Lusch [8]	"The application of specialized competences (knowledge and skills) through deeds, processes, and performances for the benefits of another entity or the entity itself"
Rennecker and Lindsey [12]	A business economic activity (mostly intangible in nature), offered by one party to another to achieve a certain benefit.
Preiss [13]	Complex (or simple) task executed (within) an organization on behalf of a customer
Kotler et al.[14]	"Any activity of benefit that one party can give to another, which is essentially intangible and does not result in ownership of anything. Its production may or may not be tied to a physical product".
Chesbrough [15]	Rethinking the business through open service innovation.
Vitarlari et al. [16]	A business platform is a set of interconnected digital components that together deliver business services.

concluded that services have certain characteristics including intangibility, inseparability (of production and consumption), heterogeneity (or non-standardization), and perishability (or exclusion from the inventory).

Similarly, Tien et al. [17] have defined services as having four characteristics; information-driven; customer centric; increasingly electronic-oriented and productivity issues. It is evident from the listed characteristics above that the concept of a service includes 3 core dimensions [18], which are 1) Activities; 2) Interactions (which separate services from physical products); and 3) Solutions to customer problems or creates values.

Ainamo and Ventresca [11] argue that a service "involves a greater involvement of customers in the production process, greater difficulties in maintaining quality control standards, an absence of inventories, the relative importance of the time factor, and a particular structure of the distribution channel". Therefore, a service is more intangible, less standardised and uniform than a good [20], [21] & [14].

Most definitions of a service focus on the customer and on the fact that services are provided as solutions to customer problems [11] or create value [21]. Therefore, the working definition for services adopted here is;

"Dynamic set of activities which create value/solve a problem through the lens of the customer."

Applying this to the predictive analytics platform being considered in this paper gives a more specific definition.

"Predictive analytics services which predict customer churn from the perspective of customer retention managers."

More recent literature considers a meta-level perspective on service creation, including adopting an open innovation approach to services [15] and the emergence of business platforms, defined as, 'a package of interconnected digital components (hardware and software) that together deliver a set of business service' [16]. Gustafsson and Johnson [22] argue that a service organisation should "create a seamless system of linked activities that solves customer problems or provides unique experiences". These new directions imply that service creation requires a sound methodological underpinning that enables development of services across multiple stakeholders with a customer perspective.

In order to support this rationale, the objective of this paper, therefore, is to explore service blueprinting as a method for establishing a shared understanding of a cloud service design from the perspective of customers.

3 Service Design and Design Science Methodology

The IS discipline has being addressing the challenges of theorizing design, but not explicitly from a service development perspective. Hevner [23] sets out the foundations of developing and evaluating IT artifacts and highlights what constitutes a good Design Science design. An interactive model with theoretical inputs and an interactive development of an IT artifact are key elements of the Hevner approach [23], which also distinguishes between the two paradigms in IS research, namely 'behavioural science, which seeks to develop and verify theories that explain or predict human or organisational behaviour and Design Science, which seeks to extend the boundaries of human and organisational capabilities by creating new and innovative artifacts.' Other commentators suggest that Design Science should generate design theory and 'For design research to be accepted as scientific it must generate abstract design knowledge that makes contributions to the academic knowledge base in the form of design theories' [24]. Gregor et al. [25] adopts a broader perspective on what constitutes theory and argues that design research can, at least in some cases, contribute to a class of theory dealing with 'design and action'. The essence of a design theory is that it should answer questions of what and how by providing a description of an artifact in terms of its meta-requirements and meta-design (i.e. what), as well as its design method (i.e. how) [24].

In addition, design theories must show why the artifact provides an advance on all previous approaches to solving the problem [25]. So as well as answering questions of what and how, design theories must also explain why an artifact should work and why it should lead to a novel or improved solution [24].

The artifact instantiation can be a component of a design theory and Gregor and Jones [25] take a clear position on this question and they call for instantiations to be included as components in a design theory. They suggest that instantiations can serve as theory representations or expositions and, therefore, can contribute towards communicating and illustrating the design principles that are embodied within the design theory. The credibility of the design is, therefore, enhanced by provision of an instantiation as a working example [25].

In summary, a design theory consists of meta-requirements and six further components namely, meta-design, design method, academic grounding, practical grounding, empirical grounding, and design principles. A seventh component, an instantiation, is optional, but can play an important supporting role in demonstrating the credibility of the aforementioned components.

The authors adopt this meta-design model requiring a kernel theory that focuses on the customer perspectives of services. Service design and conceptual models of Cloud computing could advance on previous methods [25], but also allow prescribed models for future development of services, including technical specifics, on the cloud. This approach can formalize customer–oriented design science, but an appropriate service design method is required.

3.1 Service Design Kernel Theory

To fully understand the functionality and form of a service many researchers turn to service design and in this paper we wish to identify an appropriate service design method that can act as a theoretical lens to support customer oriented service co-creation and ultimately theory development. Emerging in the early 1990s [26],[27] & [28] service design tools/techniques captures not only the creativity of the development team but also the customer's needs and experiences. Therefore, service designs can be described as using "design techniques and people centered approaches in the context of new service development" [26].

Service design tools that describe the customer-centric approach are considered an essential requirement to new service development, which include a wide range of techniques including interactive story boards, personas, role play, and customer journeys [27]. Story boarding is inspired by the cinema world and it allows the designers to put together the pictures that describe the service experience in order of occurrence. Personas involve building personality types relating to age, gender, attitudes, and location in order to represent the different segments of an organisations market (ibid). These can then be role played for a customer journey (ibid). A customer journey is a user centered visualisation of the customer experience which uses the customers' language to create a picture of the customer experience (ibid). It can be supplemented with pictures and anecdotes (ibid). One mature tool among the range of service design tools is service blueprinting [19]&[29]. More recently new blueprinting methods for designing complex service systems with multiple customer value propositions and customer experience are emerging [30].

Originating in the financial services sector, the concept of service blueprinting has become an integral tool for service designers. This is evident in the literature base where service blueprinting has been utilised to depict services in various sectors including hospital outpatients [31], unemployment services [32], IT call centre [33], delivery service; vacation stay; football game; internal service innovation process [29], snack robots [34], retail banking kiosks [35] and car parking [36]. Despite this, there is limited evidence of service blueprinting in the design science literature.

Blueprinting is a method first proposed by Shostack [37],[38] & [39] and developed further by Kingman-Brundage [40] & [41] and [29] to envision expected and/or actual service processes. Service blueprinting is defined as a customer-focused approach for service innovation and service improvement [38]. Therefore, considered as an effective tool for helping an organisation to develop new services [42], service blueprinting is a technique that describes all activities that are carried out by a service provider and its customer to deliver a service. It helps create a visual depiction of the service process that highlights the steps in the process, the points of contact that take place, and the physical evidence that exists, all from a customer's point of view [29].

Mapping or visualization of services are important as it forces the service designers to examine the service from a customer perspective and reveals to the participants the myriad of dependencies and interactions cross functions that are necessary for the service [29].

3.2 Customer/Employee Service Blueprint

A customer/employee service blueprint documents the customers' interaction with the organisation via the service. A typical customer/employee or customer/ technology service blueprint consists of five components which are described in Table 2.

Table 2. Technology-Delivered Self Service Blueprint Components

Self-Service Blueprint Components	**Description**
Physical Evidence	All the tangibles that customers are exposed when a service process is being delivered &/or feedback the customer received after each contact with the service.
Customer Actions	All activities, chronically ordered, that customers undertake as part of the service delivery process.
Onstage Technology	Describes the interface between the customer and the technology
Backstage Technology	Describes the backend technology activities
Support Processes	Contains those hidden activities that are needed to make the delivery of the service possible.

The following process, according to Bitner [29], will create a service blueprint.

1. The customer actions have been chronologically mapped.
2. The actions of the contact employees and potential technology interactions are mapped. These actions are those that are visible to the customers.
3. The actions of the contact employees and technology that are invisible to the customers are mapped.
4. The supporting actions of non-contact employees that are necessary for the delivery of the service are mapped.
5. Finally, the pieces of physical evidence are added as the last piece of the blueprint.

A service blueprint is a two-dimensional picture of service process; horizontal and vertical. The horizontal axis represents the chronology of actions undertaken by the customer and provider of the service. The vertical axis distinguishes between different areas of action separated by different lines [43]. These lines include:

- **Line of interaction:** Separates the customer's actions area from the supplier's action area. Above this line, activities, choices, needs and interactions performed by customers are presented. As a result, Bitner [29] argues that a 'moment of truth' has occurred.
- **Line of visibility:** Distinguishes between actions visible and invisible for customers. Above this line one can find the "On-stage" contact and employees' actions (Front Office).
- **Line of internal interaction:** Distinguishes between front office and back office activities.

Service blueprints can describe human-to-human service innovation, as many service design developers believed that technology was not essential for service innovation [44]. However, described as an "important ingredient of innovation development" [45] technology and service innovation are closely interrelated. Rogers [46], Chesbrough et al. [47] and Spohrer [48] and Chen et al., [49] argue that technology is a critical enabler for service innovation. It is therefore important to note that services can be delivered through human-to-technology service innovation.

4 Towards a Cloud Service Design Theory

This project is funded by Enterprise Ireland's Innovation Partnership program (the Irish business development agency) and Statistical Solutions, an Irish SME that develops unique statistical software applications for statisticians, clinical researchers, data analysts and other analytical professional. The development and design team consists of academics, statistical specialist and software developers. The case sets out to explore the rhetoric relating to the impact of Cloud Computing on SMEs and this paper highlights the initial experiences of using a service blueprinting for developing a shared understanding of service development.

This section explores the resultant design decisions that emerged from the experience of the initial development of this analytics service artifact platform. To date, the definition and taxonomy of cloud services has been arbitrary in nature and, while both the literature and vendor papers have attempted to provide a consistent view of the variety of cloud services and technologies on offer, no comprehensive taxonomy has been offered [50]. However, while Esteves [50] provides such a taxonomy as well as deployment and delivery models, it does not address the issue of cloud services from a user's standpoint. In addition, Papazoglou [1] present a cloud blueprinting approach to characterise service based applications, its focus is still technological. A taxonomy of cloud services framed from a user's point of view does not appear to exist and existing definitions are excessively techno-centric.

PredictX is a predictive analytics service under development for which the user uploads historic customer data to a cloud application, where specific data that may identify customers has been removed. Essentially, PredictX adopts Edwardsson's [50] assessment of what constitutes a service as this service is considered "as a perspective on value creation through the lens of the customer". The platform allows the customer to create prediction in a self-service manner. As this is a 'preliminary' version the blueprint which is developed, it is considered to be a concept blueprint. As this service is a

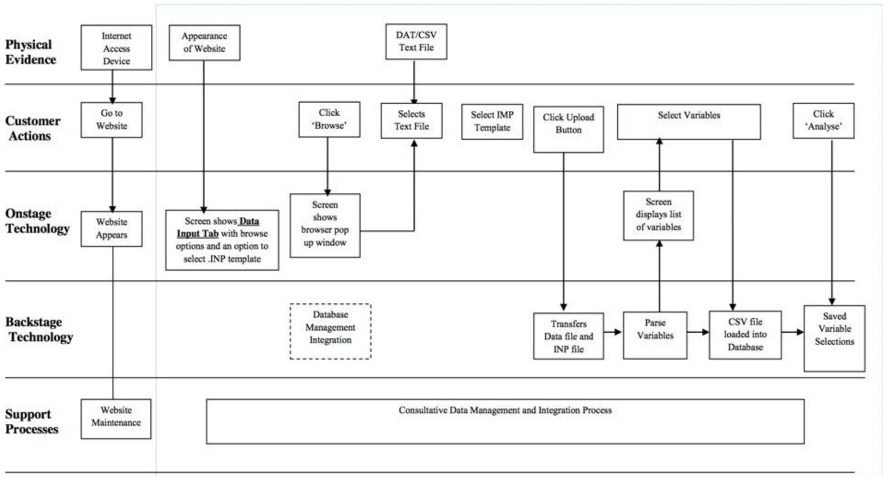


Fig. 1. PredictX Service Blueprinting Example

relatively new concept the blueprint for this new service will be presented at a high level [29]. As the service develops in the future, a more detailed blueprint can be provided. It is important to note, however, that different customer segments can have different blueprints so there may be many blueprints for one service [29].

The first part of the service blueprint for the PredictX is shown in Figure 1, which is the output of a focus group workshop of the design team, which included developers, senior managers and predictive analytics experts. The company participants were skeptical initially and limited the time set aside for the blueprinting workshop. Much to the surprise of all involved in the process, the focus group quickly understood the model and applied it to co-creating the service design. The method proved to be very intuitive and the team reached a consensus quickly with only minor discrepancies or differences in opinion. Over the duration of the development project the service blueprint evolved and as the artifact became part of the Design Science process and it in turn inspired alterations. The role of the blueprinting was sporadic and the design reached stabilization, which required customer emersion of the artifact to develop new requirements and advance the design. This is in line with the iterative aspect of the Hevner (2004) approach. The outcome of the design process is shown in figure 2, which highlights a survival curve and associated churn risk predictors of customers.

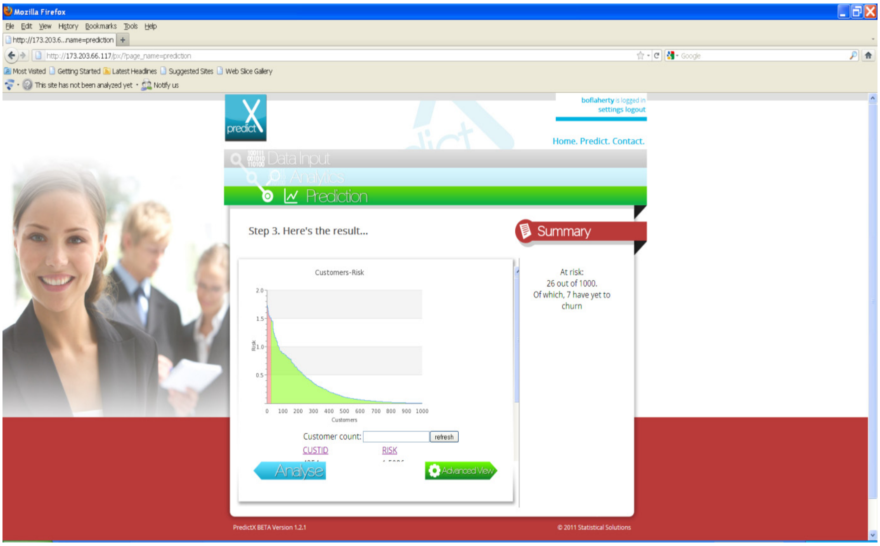


Fig. 2. PredictX Screen Shot, showing customers at risk of churning

The service blueprint also captures non-technical cloud support processes, which are an important aspect of the revenue model for cloud services. Services by their nature accumulate recurring revenue and these alternative revenue streams can be modeled on the blueprint. As the PredictX service blueprinting case is dependent on cloud technologies, reflecting on such a case allows the first elements of a Cloud Service Design Theory to emerge. One could argue that the service blueprint unclutters the technical detail and forces the designers to focus on the customer perspectives. Conversely service blueprinting lacks technical specificity, once the shared design has been achieved; it can then be used to define the technical implementation details, such as data storage and data visualisation etc.,

Accordingly, specific cloud computing technical implementation details are overlaid on Figure 3, which maps the cloud services into Customer Action, Navigation, Data Visualisation, Data Upload, Processing and Retrieval and Cloud Support Services. The cloud model also lets developers decide on implementation details, which are customer driven and can be systematically developed. The Customer actions relate to web pages or groups of web pages that fulfill the visible user interface elements, which occur in sequence and the navigation design allows customer interaction across the service. This extension to the service blueprint, helps navigation design and defines the navigation logic require for the customer to complete the service task. Data Upload formats, data storage structure and database systems, such as mySql or hadoop, in the case of big data implementations etc., can all be selected by the developers at this time. Data visualisation can also be implemented as code, implemented using open source or commercially available solutions, such as crystal reports or java script based visualization libraries.

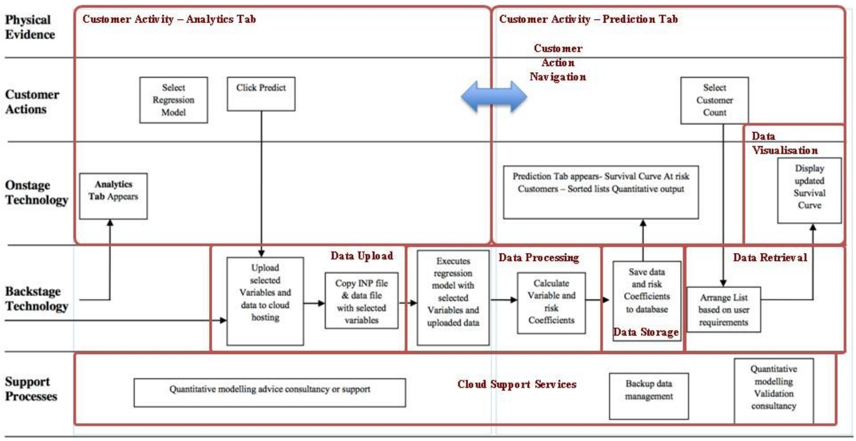


Fig. 3. Service Blueprint, with an overlay of technical cloud implementation specifics

To date, the definition and taxonomy of cloud services has been arbitrary in nature and, while both the literature and vendor papers have attempted to provide a consistent view of the variety of cloud services and technologies on offer, no comprehensive taxonomy has been offered [49]. However, while Esteves [49] provides such a taxonomy as well as technical deployment and delivery models, it does not address the issue of cloud services from a user's standpoint.

This paper set out to explore the development of a Cloud Service Design Theory and the theoretical outcome of developing a predictive analytics cloud service is represented in table 3. The components of the emerging design theory follows Walls [24] and the key kernel theory is Service Blueprinting, which ensures customer centered design and Cloud Technology mapping, which emerged on reflection from the experience of developing the PredictX service. The development of this platform is ongoing and more sophisticated blueprinting experience and models are expected.

Table 3. Components of an Cloud Service Design Theory (CSDT)

Design Product	
Meta-Requirement	Absolute simplicity and accessible to non-quantitative customers. Ease of use and hidden complexity
Meta-design	Non quantitative customers can run complex predictive models.
Kernel theories	Service Blueprinting
Testable design product hypothesis	Ease of use and non complexity.
Design Process	
Design Method	A description of procedure(s) for artefact construction.
Kernel Theories	Service Blueprinting & Cloud taxonomies.
Testable design process hypotheses	Consistent with the meta design.

5 Conclusion

This paper emerged from the experience of developing a predictive analytics service for deployment using cloud computing. The development team was faced with the challenge of defining a shared understanding of the required service. The system was intended for non-quantitative customers, so ease of use and no numerical complexity was a meta-design requirement. The service blueprinting, service design approach was adopted and it successfully facilitated the co-creation of a shared understanding, which became the requirements document for the application development. The service blueprint paradigm does make the developers consider the design from the customer's perspective, but it lacks a mechanism for being more specific with technical implementation details.

The implementation is commercial and the platform will continue to evolve. This will allow further validation and design interventions, including customization for new niche market needs. In addition, design theories must show why the artifact provides an advance on all previous approaches to solving the problem [25] and lead to a novel or improved solution [24]. This can be analysed and documented in future implementations and customer uptake and experiences will also support this validation.

The design science approach, as proposed by Hevner [23] & Walls [24] provided the framework for developing theory from the experience of developing a technology-delivered self-service blueprint for PredictX. The described cloud service design theory consists of two phases. The first phase uses Service Blueprinting as a lens for capturing customer centered services through co-creation and iterative evolution of the service artifact. The second phase defines the blueprint in cloud specific technical terms. Walls et al. [24] also identify various levels of impact of design theories, which can vary from facilitating designs through a common language to a framework for generating new insights for describing a new class of Information Systems. While this service is in its early stages, we believe that this approach can enhance customer centric service design for cloud computing. More testing and service implementations are required, which will ultimately drive the evolution of this cloud service design theory.

References

1. Papazoglou, M., van den Heuvel, W.J.A.M.: Blueprinting the cloud. IEEE Internet Computing 15(6), 74–79 (2011)
2. Nguyen, D., Lelli, F., Papazoglou, M., van den Heuvel, W.: Blueprinting Approach in Support of Cloud Computing. Future Internet 4, 322–346 (2012)
3. TDWI Research “Predictive Analytics,” What Works in Data Integration. TDWI Research, vol. 23, p. 49 (2007)
4. Hadden, J., Tiwari, A., Roy, R., Ruta, D.: Computer Assisted Customer Churn Management: State-Of-The-Art and Future Trends. Computers & Operations Research 34(10) (2007)
5. Dass, R., Jain, R.: An Analysis on the factors causing telecom churn: First Findings. In: AMCIS 2011 Proceedings (2011)
6. Lovelock, C.: Services Marketing. Prentice-Hall, Englewood Cliffs (1991)
7. Zeithaml, V.A., Bitner, M.J.: Services Marketing: Integrating Customer Focus Across the Firm. McGraw-Hill, New York (2003)
8. Vargo, S.L., Lusch, R.F.: Evolving to a new dominant logic for marketing. Journal of Marketing 68, 1–17 (2004)
9. Edgett, S., Parkinson, S.: Marketing for service industries – a review. The Service Industries Journal 13(3), 19–39 (1993)
10. Hill, T.P.: On Goods and Services. The Review of Income and Wealth 23(4), 314–339 (1977)
11. Gronroos, C.: Service Management and Marketing: Managing the Moment of Truth in Service Competition. Lexington Books, Lexington (1990)
12. Rennecker, J., Godwin, L.: Delays and Interruptions: A Self-Perpetuating Paradox of Communication Technology Use. Information and Organization 15, 247–266 (2005)
13. Preiss, K.: Where Are the Smarts Located in a Smart Business Network? In: Vervest, P., van Heck, E., Preiss, K., Pau, L. (eds.) Smart Business Networks, ch. 7. Springer, Germany (2005)
14. Kotler, P., et al.: Principles of marketing. Pearson Education (2008)
15. Chesbrough, H.: Open Services Innovation: Rethinking Your Business to Grow and Compete in a New Era. Jossey-Bass (January 2011)
16. Vitalari, N., Shaughnessy, H.: The Elastic Enterprise: the New Manifesto for Business Revolution. Olivet Publishing (2012)
17. Tien, J., Berg, D.: A case for service systems engineering. Journal of Systems Science and Systems Engineering 12(1), 13–38 (2003)
18. Edvardsson, B., Gustafsson, A., Roos, I.: Service Portraits in Service Research — A Critical Review. International Journal of Service Industry Management 16(1), 107–121 (2005)
19. Ainamo, A., Ventresca, M.: Services innovation: sourcing in lessons from true professionals. In: The Berkeley-Tekes Service Innovation Conferences. Haas School of Business, Berkeley (2007)
20. Berry, L.L.: Services Marketing is Different. Business 30, 24–28 (1980)

21. Gummesson, E.: Relationship marketing: its role in the service economy. In: Glynn, W.J., Barns, J.G. (eds.) Understanding Services Management, pp. 224–268. Wiley, Chichester (1995)
22. Gustafsson, A., Johnson, M.: Competing in the Service Economy. Jossey-Bass, San Francisco (2003)
23. Hevner, A.R., March, S.T., Park, J., et al.: Design Science in Information Systems Research. MIS Quarterly 28(1), 75–105 (2004)
24. Walls, J.G., Widermeyer, G.R., El Sawy, O.A.: Assessing Information System Design Theory in Perspective: How Useful was our 1992 Initial Rendition? Journal of Information Technology Theory and Application 6, 43–58 (2004)
25. Gregor, S., Jones, D.: The Anatomy of a Design Theory. Journal of the Association for Information Systems 8, 312–335 (2007)
26. Mager, B.: Service Design; A Review. KISD, Koln (2004)
27. Erlhoff, M., Marshall, T., Board of International Research in Design: Design dictionary: perspectives on design terminology. Birkhäuser Verlag (2008)
28. Segelstrom, F., Holmlid, S.: Visualizations as tools for research: Service Designers on Visualizations. In: Engaging Artifacts, Oslo (2009)
29. Bitner, M., Ostrom, A., Morgan, F.: Service blueprinting: A practical technique for service innovation. California Management Review 50(3), 66–94 (2008)
30. Patrício, L., Fisk, R., Cunha, J., Constantine, L.: Multilevel Service Design: From Customer Value Constellation to Service Experience Blueprinting. Journal of Service Research (2011)
31. Randall, L.: Perceptual blueprinting. Managing Service Quality 3(4), 7–12 (1993)
32. Erlhoff, M., Marshall, T., Board of International Research in Design: Design dictionary: perspectives on design terminology. Birkhäuser Verlag (2008)
33. Sparagen, S., Chan, C.: Service Blueprinting: When Customer Satisfaction Numbers are not enough. In: International DMI Education Conference. ESSE Business School, Cergy-Pointoise, France (2008)
34. Lee, M.K., et al.: The snackbot. In: Proceedings of the 4th ACM/IEEE International Conference on Human Robot Interaction - HRI 2009, La Jolla, California, USA, p. 7 (2009), http://portal.acm.org/citation.cfm?id=1514095.1514100 (accessed January 10, 2011)
35. Wreiner, T., Martennson, I., Arnell, O., Gonzalez, N., Holmlid, S., Segelstrom, F.: Exploring Service Blueprints for Multiple Actors: A Case Study of Car Parking Services. In: DeThinkingService ReThinkingDesign. First Nordic Conference on Service Design and Service Innovation, Oslo (2009)
36. Murphy, C.: Service Blueprinting –A Lens for Service Design in Retail Banking, Unpublished Thesis, University College Cork (2011)
37. Shostack, G.L.: How to Design a Service. European Journal of Marketing 16(1), 49–63 (1982)
38. Shostack, G.L.: Designing services that deliver. Harvard Business Review (1984)
39. Shostack, G.L.: Service Positioning Through Structural Change. Journal of Marketing 511987, 34–53 (1987)
40. Kingman-Brundage, J.: Service mapping: gaining a concrete perspective on service system design. In: Eberhard, E.S., Christopher, W.F. (eds.) The Service Quality Handbook, pp. 148–163. Amacon, New York (1993)
41. Kingman-Brundage, J.: Service mapping: back to basics. John Wiley & Sons, Chichester (1995)

42. Hollins, B., Shinkins, S.: Managing service operations: design and implementation. Sage Publications (2006)
43. Fließ, S., Kleinaltenkamp, M.: Blueprinting the service company managing service processes efficiently. Journal of Business Research 57, 392–404 (2004)
44. Jong, J.D., Vermeulen, P.A.M.: Organizing successful new service development: a literature review. Management Decision 41, 844–858 (2003)
45. Vermeulen, P.A.M., Dankbaar, B.: The Organisation of Product Innovation in the Financial Sector. The Service Industries Journal 22, 77–98 (2002)
46. Rogers, E.M.: Diffusion of Innovations Fourth. Free Press (1995)
47. Chesbrough, H., Spohrer, J.: A research manifesto for services science. Communication of the ACM 49(7), 35–40 (2006)
48. Chen, J., Tsou, H.: Information technology adoption for service innovation practices and competitive advantage: the case of financial firms (2007), http://informationr.net/ir/12-3/paper314.html
49. Esteves, R.: A Taxonomic Analysis of Cloud Computing. In: 1st Doctoral Workshop in Complexity Sciences ISCTE-IUL/FCUL (2011)
50. Edwardsson, B., Gustafsson, A., Roos, I.: Service Portraits in Service Research — A Critical Review. International Journal of Service Industry Management 16(1), 107–121 (2005)
51. Jong, J.D., Vermeulen, P.A.M.: Organizing successful new service development: a literature review. Management Decision 41, 844–858 (2003)

Towards a Normalized Systems Analysis Method: A Design Science Project Incorporating Empirical Research Methodologies

Philip Huysmans and Jan Verelst

Department of Management Information Systems, University of Antwerp, Belgium
{philip.huysmans,jan.verelst}@ua.ac.be

Abstract. Normalized Systems provides a practical way of developing information systems, adhering to a sound theoretical basis, through the so-called pattern expansion of software elements. However, the specification for these elements still needs to be very fine-grained. As a result, it is not straightforward for analysts who lack experience with Normalized Systems software to provide the specification of these elements. Therefore, we initiate a research project to design an analysis method geared towards the development of Normalized Systems software systems. In order to structure this research, we will use the design science methodology. Since many Normalized Systems projects are currently being executed by expert programmers, we will base our first design iterations on empirical observations of these projects. While empirical methods are often integrated in design science projects, there are currently no clear guidelines on how both research methods can and should be combined in a rigorous way. In this paper, we therefore explore a mixed methods research approach to provide a sound methodological approach for this research project.

1 Introduction

The design research method has recently been introduced in IS research as a valuable research method. Proponents of the design research method have argued that IS researchers should more often adopt an engineering perspective by creating and evaluating IT artifacts that solve organizational problems [1–3].

Design research is a separate research method and can be used as the single research approach in a research project. However, it is accepted in literature that empirical research methods can be used as part of a design research project, especially during the problem identification and evaluation phases. It is, for example, common to use research approaches such as case studies and field studies or data collection techniques such as interviews and surveys in the evaluation stage of the design research process [2, 1]. Similar to these approaches, we intend to use empirical research methods in the first design iterations for our research project, i.e., an analysis method for developing Normalized Systems applications.

Unfortunately, there are currently no guidelines on how both research methods can and should be combined in a coherent manner. To address this issue, we

M. Helfert and B. Donnellan (Eds.): EDSS 2012, CCIS 388, pp. 112–123, 2013.
© Springer International Publishing Switzerland 2013

propose in this paper a mixed methods approach to combining empirical and design research methods. The mixed methods approach is a research approach that originated in the social sciences and refers to combining both qualitative and quantitative research methods within a single study [4]. The combination of qualitative and quantitative research methods has also been advocated within the IS community [5, 6]. The idea underlying the mixed methods approach is that "*[...] both quantitative and qualitative research are important and useful. The goal of mixed methods research is not to replace either of these approaches but rather to draw from the strengths and minimize the weaknesses of both in single research studies and across studies*" [4, p. 14–15]. In a similar vein, we argue in this paper for combining empirical and design research methods in a single study in order to strengthen the overall research effort. To this end, we propose to use the term mixed methods approach to include research designs combining empirical (i.e., qualitative and/or quantitative) and design research methods. Although the idea of using empirical research methods within a design research project is not new, the main contribution of this paper is that we propose a coherent approach to combining both research methods.

This paper is structured as follows. In Section 2, we introduce a framework to coherently incorporate empirical research approaches in a design science project. In Section 3, we illustrate the use of our framework by applying it to our research project, and discuss the implications on our methodological approach.

2 Methodological Framework

In this section, we introduce a methodological framework to use empirical research approaches in a design science project. We argue first how empirical methodologies are already used in design science projects, and introduce the mixed methods approach as a structure for our framework. We then discuss the framework and its resulting research designs.

2.1 Empirical Methodologies in Design Science

Several examples can be found in the design research literature of how empirical research can complement the design research process. The use of these empirical research methods can often be found in the evaluation stage of the design research process. Hevner et al. mention case studies and field studies as valid observational evaluation methods [2]. Siau and Rossi describe six empirical evaluation techniques, namely surveys, laboratory experiments, field experiments, case studies, action research and verbal protocol analysis [7]. Some authors further argue that empirical research methods are even inherent to the evaluation phase of design research and that some IT artifacts must be evaluated using an empirical approach [1]. Nevertheless, it is important to note that the use of empirical research methods is not limited to the evaluation phase, but can also be found in the problem identification and solution design phases. An example of the former is provided by Saat et al. who employ quantitative research methods (i.e., an on-line survey as the data collection technique and exploratory factor analysis and hierarchical cluster analysis as data analysis techniques) in the problem identification phase to distinguish between different situations of business/IT alignment [8]. The latter is illustrated by Tremblay et al. who use the focus group approach during the refinement of the artifact design [9] . The most popular empirical research methods include case studies [10–14], focus groups [15, 9], and experiments [16, 17].

While empirical research methods are used frequently in design science projects, no explicit guidelines are currently available. For example, exemplary design science publications which are referenced in methodological design science papers [1, 2] vary in their reporting of the use of empirical methods. While some authors report on both the methodology and the (empirical) methodological sources which are adhered to [11], others only report on the empirical research approach [12, 15, 13], or do not discuss empirical methodology at all [10]. Therefore, we propose a mixed methods approach to frame the use of empirical research methods in a design science project.

2.2 Mixed Methods

The term "*mixed methods*" research is used in literature to refer to studies in which qualitative and quantitative research methods are combined. Although a number of definitions of mixed methods research have been proposed, a view that underlies most definitions is that mixed methods research is "*the class of research where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study*" [4, p. 17].

A mixed methods study essentially consists of two *components*. Each component corresponds to a study that is conducted using either qualitative or quantitative methods [18]. There are three main factors that influence the design of a mixed methods study: the *theoretical drive* of the research, the *pacing* of the study components, and the *point of interface* [18]. First, the *theoretical drive of the project* refers to the overall conceptual direction of the research project [18]. It indicates whether the overall character of the research is qualitatively-driven or quantitatively-driven. This theoretical drive therefore determines which component of the research is considered dominant in the context of the overall research project. Since its aim is to support the core component, its results may not be separately publishable [18]. Second, the *pacing of the components* refers to how both components are synchronized in the context of the overall research project [18]. Two main modes of synchronization are available: concurrent or sequential [18, 19]. In sequential research designs, the two components are conducted at different times and one project can be said to further build upon the results of the previous study [19, 20, 18]. The output of the first component is therefore the input for the second component. In concurrent research designs, the supplementary component is conducted simultaneously with the core component. The supplementary component therefore starts and ends during, and is performed within the context of, the core component. Third, the *point of interface* refers to the stage at which the results from both components are combined or integrated [18]. The most common stages at which integration takes place is during data analysis or data interpretation [18, 19]. For example, if integration takes place during data interpretation, both components are conducted separately, and the results from both studies are interpreted when writing down the findings with respect to the overall study, thereby considering how the results of both components complement each other.

The main advantage of mixed methods research is that it allows the researcher to combine the respective strengths of multiple research methods in order to provide an answer to the research questions [4, 19]. Gaining a deeper understanding through the use of multiple methods also respects the fact that certain phenomena are inherently complex [21]. In addition, the use of multiple methods allows to use the strength of one method to complement the other, thereby offering insights that both methods alone could not have provided [20, 19]. For example, quantitative research typically focuses on confirmatory research based on a large sample. The use of a subsequent qualitative study could provide more in-depth insight into the results of the quantitative study.

2.3 Combining Design Science and Empirical Methodologies

While the term mixed methods research has been used in literature to refer to the combination of qualitative and quantitative research methods, we argue that the term mixed methods research can also be used for research designs that combine design research with empirical (i.e., qualitative or quantitative) research methods. This is acknowledged by [18] who define mixed methods as "*the incorporation of one or more methodological strategies, or techniques drawn from a second method, into a single research study, in order to access some part of the phenomena of interest that cannot be accessed by the use of the first method alone.*" [18, p. 9]. When we aim to combine empirical and design science research methods, various combinations are possible based on the theoretical drive, pacing, and point of interface factors. In this paper, we focus on research designs where the design science component is the theoretical drive. Based on the pacing, we can differentiate between research designs where (1) the empirical component precedes the design component; (2) the design component precedes the empirical component; and (3) the empirical and design component are executed concurrently. In the concurrent research design, we can differentiate between multiple designs based on the point of interface. The design research method prescribes three major phases: problem identification, solution design and evaluation. The empirical research component can be used to support each of these three phases in the design research. Based on these different phases, we differentiate between three different research designs. The resulting research designs are summarized in Table 1. In this table, we use the "+" sign to denote a concurrent research design, and a "→" to denote a sequential research design. The component which provides the theoretical drive is notated in capital letters. We will now briefly discuss each of these research designs.

Table 1. Mixed methods research designs with emphasis on design research process

Research Design	Notation	Point of Interface
Concurrent exploratory	DESIGN + empirical	problem identification phase of the design research component
Concurrent creative	DESIGN + empirical	solution design phase of the design research component
Concurrent evaluative	DESIGN + empirical	evaluation phase of the design research component
Sequential exploratory	empirical → DESIGN	interpretation phase of the empirical research component
Sequential explanatory	DESIGN → empirical	communication phase of the design research component

Concurrent Exploratory Research Design: The empirical research component may assist in the problem identification phase of the design research process by gaining a better understanding of the problem that will be addressed by the artifact that will be developed in the design research component. As a consequence, this research design is *exploratory* in nature. The empirical research component can aid in understanding vaguely defined problems, or in understanding the root causes in case the design research component is used to solve a problem described by symptoms. This research design has been employed by, for example, Saat et al. [8].

Concurrent Creative Research Design: The use of an empirical research component within the build phase of the design research component may assist in the development of the artifact. This research design has therefore a *creative* nature. Empirical research can contribute to obtaining data that can be used to refine the artifact in the next iteration of the build phase. This is especially the case when tacit knowledge that is held by experts in the field must be made explicit to allow for the design of the artifact. In that case, empirical research methods can be used to extract this knowledge. In addition, one of the tenets of the design research method is that it emphasizes the use of insights from other fields [22]. The use of empirical research methods can therefore assist in the construction of an artifact by detecting patterns of successful actions in other—but similar—contexts [23]. Examples of this research design can be found in Tremblay et al. [9] and Baloh and Desouza [12].

Concurrent Evaluative Research Design: The empirical research component is used within the evaluation phase of the design research component to assist in determining whether the artifact provides a good solution to the observed problem. The nature of this research design is therefore *evaluative*. The empirical research component is fully contained in the evaluation phase of the design research component (i.e., it starts and ends within this phase). The use of empirical research methods to perform the evaluation of an artifact is well-accepted in design research literature. It has indeed been noted that the organizational context in which the artifact will be used may require an evaluation using empirical research methods [1]. Numerous examples of the use of empirical research methods to support the evaluation of an artifact can be found in literature [9, 11, 16, 17, 10].

Sequential Exploratory Research Design: Since the empirical research component is performed first, the data for the empirical component is gathered before the design research component is initiated. This research design has an exploratory nature since it will explore or describe a certain phenomenon that will be the topic of a subsequent design research component. Additionally, this research design can be applied when certain issues occur during a empirical study that motivate a design research project. An example of this research design is provided by Rothenberger [14].

Sequential Explanatory Research Design: In this research design, the artifact that was developed as part of the design research component forms the object of investigation in the subsequent empirical research component. The nature of the research design is *explanatory* since the aim of the empirical research component is to explain why or how the artifact that was developed in the design research component contributes to the solution of a given problem. This corresponds to the conceptualization of March and Smith who state that the build and evaluate phases of a design research project are followed by the theorize and justify phases of a empirical research project [24].

3 Towards a Normalized Systems Analysis Method

In this section, we elaborate on the methodological approach we take to design a Normalized Systems analysis method. Therefore, we first introduce Normalized Systems, and motivate the need for an analysis method. We then select an appropriate research design, and elaborate on the empirical aspects of our methodology. Finally, we present some preliminary findings of our approach.

3.1 Normalized Systems

The Normalized Systems (NS) theory starts from the postulate that software architectures should exhibit *evolvability* due to ever changing business requirements, while many indications are present that most current software implementations do not conform with this evolvability requisite. Evolvability in this theory is operationalized as being the absence of so-called *combinatorial effects*: changes to the system of which the impact is related to the size of the system, not only to the kind of the change which is performed. When changes are dependent on the size of the system and the system itself keeps on growing, changes proportional to the size of the system become ever more difficult to cope with (i.e., require more efforts) and hence hamper evolvability. Normalized Systems theory proposes four theorems, which have been proven to be necessary conditions to obtain software architectures in absence of combinatorial effects: (1) *Separation of Concerns*, requiring that every change driver (concern) is separated from other concerns in its own construct; (2) *Data Version Transparency*, requiring that data entities can be updated without impacting the entities using it as an input or producing it as an output; (3) *Action Version Transparency*, requiring that an action entity can be upgraded without impacting its calling components; (4) *Separation of States*, requiring that each step in a workflow is separated from the others in time by keeping state after every step. These theorems are not new by themselves. Rather, they explicitly state heuristic design knowledge. For every theorem, it has been proven that a violation against it results in the occurrence of combinatorial effects.

The systematic application of the principles leads to a very fine-grained modular structure, which could form an additional design complexity on its own when performed "from scratch". Therefore, NS theory proposes a set of five elements as encapsulated higher-level patterns complying with the four theorems:

- *data elements*, being the structured encapsulation of a data construct into a data element (having get- and set-methods, exhibiting version transparency, etcetera);
- *action elements*, being the structured encapsulation of an action construct into an action element;
- *workflow elements*, being the structured encapsulation of software constructs into a workflow element describing the sequence in which a set of action elements should be performed in order to fulfill a flow;
- *connector elements*, being the structured encapsulation of software constructs into a connector element allowing external systems to interact with the NS system without calling components in a stateless way;
- *trigger elements*, being the structured encapsulation of software constructs into a trigger element controlling the states of the system and checking whether any action element should be triggered accordingly.

Each of the elements is a pattern as they represent a recurring set of constructs: besides the intended, encapsulated core construct, also a set of relevant cross-cutting concerns (such as remote access, logging, access control, etcetera) is incorporated in each of these elements. For each of the patterns, a detailed class structure is described [25]. It is further described how the patterns facilitate a set of anticipated changes in a stable way [26]. In essence, these elements offer a set of building blocks, offering the core functionalities for contemporary information systems. Consequently, as such detailed description is provided for each of the five elements, a NS application can be considered as an aggregation of a set of instantiations of the elements.

Based on the set of five elements, the actual software architecture of NS conform software applications can be generated relatively straightforward. By providing a set of parameters in so-called descriptor files, a custom instance of the class structure of any element can be generated. This is referred to as *pattern* *expansion*. Manual coding only needs to be performed in the implementation class. As a result, coding efforts are concentrated in a single class for every instantiated element.

Based on the elements and expanders, NS applications can be developed. However, no analysis method is currently available for specifying the descriptors for the elements. In their book, Mannaert and Verelst claim that the large amount of IS development methods can be considered to be complementary to the specific requirements of the NS theory [25]. For example, traditional approaches for modeling processes (e.g., BPMN) and data (e.g., entity-relationship diagrams) can be used. However, specific implications of the NS theory need to be taken into account. For example, constructs such as association classes and inheritance can be used initially in data modeling, but should be mapped to separate elements when defining data elements [25]. To our knowledge, no method currently provides such guidelines. As a result, the correct application of the implications of NS theory is the responsibility of the analyst.

Using this approach, experienced NS programmers have been able to successfully operationalize several applications. However, it became clear that, when inexperienced programmers use the expanders, several issues arise. Therefore, a need was articulated for an analysis method for NS applications which can guide analysts who are not NS-experts towards a usable specification of descriptors. This need is the direct motivation for our design science research project.

3.2 Selecting of a Methodological Approach

In the previous section, we motivated the need for a NS analysis method based on the difficulty to specify NS descriptors. The descriptors for these elements remain very fine-grained. As a result, specifying these descriptors is not straight-forward. Moreover, it has been observed that during the usage of existing methodologies, advantages of the NS expanders are not fully utilized. For example, by focusing too long on the complete capturing of end user requirements, delays in the development process can occur, which is suboptimal as the NS expanders allow analysts to develop prototypes very quickly, and confirm requirements with end users. Because of these reasons, a specific analysis method should be constructed which (1) takes into concern the elimination of combinatorial effects; (2) uses the advantages of the NS expanders; and (3) provides as a deliverable the descriptors for the five NS elements. This description fits the requirements of a problem statement for a design science project. The three mentioned reasons articulate a clear need, and can be used as a starting point for defining evaluation criteria. If more clarity was required for the concrete problem statement, we could have initiated a *concurrent exploratory* or *sequential exploratory* research design. In a exploratory research design, an empirical research component is used to support the problem identification phase to capture requirements from stakeholders for the design of the artifact (i.e., the question of *what* artifact should be developed).

As described in Section 3.1, several NS applications have already been developed by knowledgeable programmers. By building on their knowledge and experience, valuable insights for the NS analysis method can be gained. Consequently, we will employ empirical methods during the design of the method itself, and use a *concurrent creative research design*. In the concurrent creative research design, the empirical research component is conducted within the build phase to inquire stakeholders about the solution or artifact itself (i.e., the question of *how* the artifact should be developed).

Various case studies will be performed as input for the initial design of the analysis method. Following to the mixed methods approach, we adhere to guidelines for case study research during this phase [27, 28]. These guidelines demand the explicit reporting of the sample selection, informant selection, the applied data gathering technique and the procedure for data analysis. For each case study, the table represented in Table 2 will be completed. For an initial case study, we selected a project where initial problems with the specification of NS descriptors had been observed. These problems had been resolved once an experienced NS programmer was added to the project. Moreover, we assured that the resolved issues did not have a technical cause. This allowed us to ensure that the project contained analysis-level insight which could be made explicit by the NS programmer. Using the key informant method [28], we selected the NS programmer as the primary respondent. We used expert interviews as the primary source of data gathering [29, 27, 28]. In subsequent cases, we plan to employ observation as an additional data gathering technique, to obtain more complete data [27]. We applied open coding during data analysis [29]. The coding scheme will be updated to facilitate cross-case analysis once additional cases are performed. Moreover, negative coding will be employed to ensure consistency [29].

Table 2. Empirical Requirements

	Case Study 1	Case Study 2
Sample Selection	Analysis-level issues	...
Informant Selection	NS programmer	...
Data Gathering Technique	Expert interviews	...
Data Analysis Procedure	Open coding	...

3.3 Preliminary Results

Based on the initial case study, several lessons learned can already be made explicit.

Lesson 1: Focus on the data model first, and get it right. The case study showed that the initial focus in the NS analysis process should be on the data model, which is similar to certain structured and object-oriented analysis methods. However, a first observation showed that end users and analists were able to correct several mistakes after their data model was translated into a first version of the software system using the NS expanders, which was done very early in the analysis process, after just one or two days. Therefore, the feedback processes by the end user were focused on the software, never on the models, which should be one of the fundamentals of the NS analysis method. A second difference concerns the use of inheritance in such data models: this seemed to lead to high coupling between business concepts and was therefore not used at all. Third, evolutionary prototyping was used, continually refining and regenerating the prototype, as opposed to throw-away prototyping. This showed to flexiblity offered by the NS theory and the NS expanders. However, certain action and workflow elements exhibited dependencies on the data model. Also some customizations that were required to the generated code exhibited such dependencies, which suggests that the NS analysis should first focus on getting the data model right.

Lesson 2: Scoping complexity The case study shows that one or a handful extra requirements may make a data and/or process model highly inadequate and actually "break" the model(s). This can happen both by adding non-functional requirements (which e.g. require a substantial increase in the robustness of the system) as well as by adding functional requirements (which e.g. require a substantial generalization of concepts in the data model, when for example the concept 'invoice' is extended from national to international invoices). Therefore, the analist should first have a reasonably thorough understanding of the complexity in the application domain before determining the scope of the current development effort.

Also, functionality for standard business transactions was combined with highly innovative requirements that were specific to the organization. Instead of working inductively, traditional analysis approaches often take too much complexity into account. As a result, delays can occur and initial delivery of software can be delayed by several months or more. Often, as many requirements as possible are included because applications are perceived to be difficult to adapt afterwards. Since the NS theory focuses on the evolvability of software, changes in requirements are considered to be normal. Therefore, the NS analysis method should focus on an inductive path: a small core set of requirements should be analyzed and developed first. Only when this set of requirements is successfully translated into a working system (preferably in production), the more advanced requirements should be addressed, thereby focusing both on quick results as well as allowing time for learning processes, but without the risk of substantial delays in delivery of systems.

The lessons learned will be aggregated over the various case studies. This will conclude a first iteration in the design science project. Together, these lessons will be the basis for the selection of an analysis method which will be extended to incorporate the NS-specific requirements, or the design of a new analysis method.

4 Conclusions

In this paper, we introduced a framework to incorporate empirical research methods in a design science research project. While many design science researchers use empirical methods, no coherent approach to combine both methodologies is available. A lack of rigor when applying empirical methodologies could lead to the perception that design science researchers are less concerned about rigor in general. By explicitly isolating both research approaches using the mixed methods structure, two contributions can be claimed. First, the isolation of an empirical research component will encourage design science researchers to conduct the research using the rigorous standards of that component. Second, the the framework may expose design science researchers to a larger set of empirical research approaches and techniques. For example, we mentioned the use of observations instead of interviews for our own research project. As a third contribution, the five different research designs can be mentioned. We elaborated on their use, and provided examples of published design science projects which could be described by these designs. Moreover, we illustrated the application of this framework by outlining the methodological approach of our design science research project, i.e., the development of a NS analysis method. For this project, we presented some initial results of the applied empirical methods.

References

1. Peffers, K., Tuunanen, T., Rothenberger, M.A., Chatterjee, S.: A design science research methodology for information systems research. Journal of Management Information Systems 24(3), 45–77 (2007)
2. Hevner, A.R., March, S.T., Park, J., Ram, S.: Design science in information systems research. MIS Quarterly 28(1), 75–105 (2004)
3. Gregor, S., Jones, D.: The anatomy of a design theory. Journal of the Association for Information Systems 8(5) (2007)
4. Johnson, R.B., Onwuegbuzie, A.J.: Mixed methods research: A research paradigm whose time has come. Educational Researcher 33(7), 14–26 (2004)
5. Mingers, J.: Combining IS research methods: Towards a pluralist methodology. Information Systems Research 12(3), 240–259 (2001)
6. Kaplan, B., Duchon, D.: Combining qualitative and quantitative methods in information systems research: A case study. MIS Quarterly 12(4), 570–586 (1988)
7. Siau, K., Rossi, M.: Evaluation techniques for systems analysis and design modelling methods - a review and comparative analysis. Inf. Syst. J. 21(3), 249–268 (2011)
8. Saat, J., Winter, R., Franke, U., Lagerstroem, R., Ekstedt, M.: Analysis of it/business alignment situations as a precondition for the design and engineering of situated it/business alignment solutions. In: Proceedings of the 44th Hawaii International Conference on System Sciences (HICSS-44), Kauai, HI, January 4-7 (2011)
9. Tremblay, M.C., Hevner, A.R., Berndt, D.J.: Focus groups for artifact refinement and evaluation in design research. Communications of the Association for Information Systems 26(1), 599–618 (2010)
10. Albert, T.C., Goes, P.B., Gupta, A.: GIST: A model for design and management of content and interactivity of customer-centric web sites. MIS Quarterly 28(2), 161–182 (2004)
11. Arnott, D.: Cognitive biases and decision support systems development: a design science approach. Information Systems Journal 16(1), 55–78 (2006)

12. Baloh, P., Desouza, K.: Towards a knowledge needs-technology fit model for knowledge management systems. In: Proceedings of the 4th International Conference on Design Science Research in Information Systems and Technology (DESRIST 2009), May 7-8. ACM, New York (2009)
13. Peffers, K., Gengler, C.E., Tuunanen, T.: Extending critical success factors methodology to facilitate broadly participative information systems planning. Journal of Management Information Systems 20(1), 51–85 (2003)
14. Rothenberger, M.A.: Project-level reuse factors: Drivers for variation within software development environments. Decision Sciences 34(1), 83–106 (2003)
15. Parsons, J., Wand, Y.: Using cognitive principles to guide classification in information systems modeling. MIS Quarterly 32(4), 839–868 (2008)
16. Xu, J., Wang, G.A., Jiexun, L., Chau, M.: Complex problem solving: Identity matching based on social contextual information. Journal of the Association for Information Systems 8(10), 525–545 (2007)
17. Abbasi, A., Chen, H.: Cybergate: a design framework and system for text analysis of computer-mediated communication. MIS Quarterly 32(4), 811–837 (2008)
18. Morse, J.M., Niehaus, L.: Mixed Method Design: Principles and Procedures. Developing Qualitative Inquiry, vol. 4. Left Coast, Walnut Creek (2009)
19. Creswell, J.W., Plano Clark, V.L., Gutmann, M.L., Hanson, W.E.: Advanced mixed methods research designs. In: Tashakkori, A., Teddlie, C. (eds.) Handbook of Mixed Methods in Social and Behavioral Research, pp. 209–240. Sage Publications, Thousand Oaks (2003)
20. Morse, J.M.: Principles of mixed methods and multimethod research design. In: Tashakkori, A., Teddlie, C. (eds.) Handbook of Mixed Methods in Social and Behavioral Research, pp. 189–208. Sage Publications, Thousand Oaks (2003)
21. Greene, J.C.: Mixed Methods in Social Inquiry. Jossey-Bass, San Francisco (2007)
22. Simon, H.A.: The Sciences of the Artificial, 1st edn. The MIT Press, Cambridge (1969)
23. Frank, U.: Towards a pluralistic conception of research methods in information systems research. ICB Research Reports 7, Institut für Informatik und Wirtschaftsinformatik (ICB), Universität Duisburg-Essen (2006)
24. March, S.T., Smith, G.F.: Design and natural science research on information technology. Decision Support Systems 15(4), 251–266 (1995)
25. Mannaert, H., Verelst, J.: Normalized Systems—Re-creating Information Technology Based on Laws for Software Evolvability, Koppa, Kermt, Belgium (2009)
26. Mannaert, H., Verelst, J., Ven, K.: The transformation of requirements into software primitives: Studying evolvability based on systems theoretic stability. Science of Computer Programming 76(12), 1210–1222 (2011)
27. Yin, R.K.: Case Study Research: Design and Methods, 3rd edn. Sage Publications, Newbury Park (2003)
28. Benbasat, I., Goldstein, D.K., Mead, M.: The case research strategy in studies of information systems. MIS Quarterly 11(3), 368–386 (1987)
29. Auerbach, C.F., Silverstein, L.B.: Qualitative Data: An Introduction to Coding and Analysis. Qualitative Studies in Psychology. New York University Press, New York (2003)

Enhancing Benefits from Healthcare IT Adoption Using Design Science Research: Presenting a Unified Application of the IT Capability Maturity Framework and the Electronic Medical Record Adoption Model

Jim Kenneally[1], Martin Curley[1], Ben Wilson[2], and Michael Porter[3]

[1] Intel Corporation / NUI Maynooth
{Jim.Kenneally,Martin.G.Curley}@Intel.com
[2] Intel Corporation
ben.c.wilson@intel.com
[3] Innovation Value Institute
Michael.Porter_cons_993@nuim.ie

Abstract. This paper details how 16 acute-care hospitals from across Europe and North America where able to plan a more holistic approach to the strategy, implementation and running of electronic medical record (EMR) and general IT services. The paper outlines a design science approach within the information systems (IS) field to developing and applying here-to-fore separately utilised IS management artefacts namely; the IT Capability Maturity Framework (from IVI) and EMR Adoption Model (from HIMSS Analytics). The development of novel artefacts for their joint use allows healthcare organisations systematically improve performance and more readily realise benefits from increased levels of EMR investment. This unified application was supplemented with emerging technology adoption case-studies for healthcare. The combined benefits of this approach allow acute-care hospitals to more holistically plan IT capability enhancements towards achieving improved eHealth outcomes.

Keywords: Electronic Medical Record, Electronic Health Record, IT Capability, IT Organisational Maturity, Business Value, EHR/EMR, IT Capability Maturity Framework, IT-CMF, EMRAM, Design Science Research.

1 Introduction

Despite the economic slowdown in many OECD countries recently, public spending on health is rising at an average rate of 4.8% in 2008 and 4.1% in 2009 [1]. Romanow et al [2] state these may be unsustainable trends given the state of public finances for many countries. Average spend on health per capita for OECD countries during this period stands at $3.2K, with North America at over double that - nearly $8k. Healthcare Information Technology (HIT) is commonly touted as a common denominator of many healthcare reform plans to reduce cost and improve quality from public healthcare expenditure [3,4]. For example, implementation of basic

M. Helfert and B. Donnellan (Eds.): EDSS 2012, CCIS 388, pp. 124–143, 2013.
© Springer International Publishing Switzerland 2013

electronic healthcare records (EHR) functionality is seen as a pathway to improved care coordination and patient outcomes [5]. Furthermore, a recent analysis of peer reviewed publications on health information technology between 2007 and 2010 found that 92% reached the conclusions that there were positive overall impacts relating to; clinical outcomes, quality, efficiency and provider satisfaction [7].

While calls for increased Healthcare IT (HIT) adoption have been around for more than a decade, dissatisfaction with HIT among some healthcare providers remains a problem and a barrier to realising the potential of HIT, resulting in the effective adoption rates for HIT remaining relatively low [6, 7]. However, many countries are beginning to take proactive steps to encourage greater levels of healthcare IT adoption. In North America for example, Health Information Technology for Economic and Clinical Health (HITECT) Act is making available substantial government financial incentives (estimated at $14-27BN) to adopt certified electronic health records and use them effectively in the course of care [8]. Through to end of 2011, the Meaningful Use programme had already distributed $2.5 billion of such incentive payments.

Investing in IT alone is not enough though, what you do with it and how you do it also matters [9, 10]. A healthcare IT organisation cannot focus exclusively on technology purchasing to increase efficiency and effectiveness. How the IT function is managed, in terms of critical organisational capabilities and management activities to plan, build and run effective HIT can be an important variable to enabling better patient care and improved outcomes. In fact, the ‘human element’ is core to HIT implementation to successfully manage and realise benefits [6].

The remaining sections of this paper outline the rationale for Design Science Research (DSR), summary of DSR approach taken, challenges for healthcare information technology adoption, overview of the Healthcare IT Maturity Model, summary and conclusion.

2 Design Science Research

Two important paradigms have characterised research in Information Systems (IS) namely; behavioural science and design science. To date the predominant research paradigm in the IS field has been behavioural science research [11]. Following recent academic literature review by Buntin et al [6], the authors call for more systematic approaches to how Healthcare IT adoption challenges could be overcome and pragmatically addressed.

Hevner et al [12] argue that the goal of the behavioural science paradigm is to find what is *true* whilst the design-science approach’s goal is to find what is *effective*. Whereas behavioural science research has the potential to facilitate development of theoretical understandings to HIT adoption challenges e.g. why does increased HIT adoption not guarantee improved outcomes? DSR has the potential to deliver novel, innovative ways to address these challenges e.g. what IT artefacts will increase positive outcomes from HIT adoption? DSR is driven by the desire to improve the environment through the introduction of “new and innovative artefacts and the processes for building these artefacts” [13].

DSR "creates and evaluates IT artefacts intended to solve organizational problems" [12, P77]. Table 1 presents an artefact typology of outputs from Design Science research as defined by March and Smith [13]. Rossi and Sein [15] and Purao [16] propose a fifth artefact – listed as better theories, where DSR contributes to a better understanding of the phenomenon through reflection and abstraction.

Table 1. Design Science Research Outputs

Output	Description
Constructs	The conceptual vocabulary of a domain
Models	A set of propositions or statements expressing relationships between constructs
Methods	A set of steps used to perform a task – how to knowledge
Instantiations	The operationalization of constructs, models and methods

The types of challenges faced in the IS field require innovative solutions, as requirements are often unstable, possess complex interactions and often call upon cognitive and social skills in developing solutions [12]. DSR focuses on providing artefacts to address these typical challenges within the field of IS management [13, 17]. Additionally, March and Smith [13] identify two basic activities: build and evaluate. Build "is the process of constructing an artefact for a specific purpose" and evaluation "is the process of determining how well the artefact performs" [p. 254]. During build phase of an artefact, extensive use of theoretical and research methodologies are drawn from the existing knowledge base. Evaluation phase pertains to understanding utility – i.e. that the artefact is useful in addressing a real world problem or challenge. Furthermore, Hevner et al [12] state that utility relies on truth, however discovery of truth may actually lag the discovery of utility. The goals of DSR are relevant to the field of IS where the cadence of technological change often means theoretical research may often lag real world practitioners' needs [18].

3 Using a Design Science Research Approach

The objective of this paper is to add to the body of DSR in the IS field by establishing the utility of artefacts that enable the unified application of IT-CMF and EMRAM management approaches - under a common approach called the HIT Maturity Model (HIT-MM). An outline of the design science research approach utilised is described in Table 2 using the guidelines provided by Hevner et al, [12].

Table 2. HIT-MM Design Science Research Approach

DSR Guideline	Approach taken
Guideline 1: Design as an Artefact	DSR approach is to design artefacts that address real world problems and challenges [Hevner et al, 2004; March and Smith, 1995; Hevner, 2007,]. As previously mentioned, artefacts can take the form of constructs, models, methods and instantiations [March and Smith, 1995]. The maturity model approaches of both IT-CMF and EMRAM represent both models and methods i.e. descriptions of maturity levels and improvement roadmaps to achieve higher maturity. Both offer organisational maturity assessment tools and library of recommendations to improve maturity, codified as instantiations in capability assessment tools. While those artefacts were already in existence, the HIT-MM further refined some of these original artefacts (e.g. assessment templates, analysis tools, interpretation guides) and created new model to express the relationships and insights between IT-CMF and EMRAM. Finally, new instantiation was also researched and validated from operationalization their combined use (e.g. unified assessment approach) to deliver new insights to healthcare IS managers.
Guideline 2: Problem Relevance –	Hevner (2004) defines a problem as the 'differences between a goal state and the current state of a system'. As outlined in earlier sections, the problem relevance of the HIT-MM is driven by the challenges experienced by healthcare industry who continue to struggle with dearth of tools to assist them with healthcare IT strategy development and adoption. With worldwide IS spending to be around $62 billion dollars annually (IDC) for healthcare industry – this is a very real issue.

Table 2. (*continued*)

Guideline 3: Design Evaluation -	Due to historical popularity of behaviour science approach, many resultant research outputs are defined in a format that are skewed towards abstract levels of rigor that impedes direct application by IS practitioners to address emerging problems or opportunities [19]. DSR focuses on appropriate balance of relevance and rigor to address specific challenges in the IS field [Hevner and Chatterjee, 2010]. The HIT-MM leverages the respective research and development pedigrees of IT-CMF and EMRAM - outlined earlier, but also applies DSR approach to develop and validate their unified application within a healthcare context. Within the HIT-MM, artefact evaluation followed Hevner's [20] proposal, refinement of design during the build-evaluate cycle and field testing of the artefacts in its domain environment. Initial evaluation of combined use for IT-CMF and EMRAM began with simplified conceptualizations and representations of how both the IT-CMF and EMRAM would offer complimentary insights. Through an iterative cycle, evaluation provided continuous feedback, initially based on Descriptive evaluation method (using informed argument and scenarios with subject-matter-experts from both the IT-CMF and EMRAM) and then moving to Observational evaluation (using case studies/pilots at organisations). Artefacts were evaluated in terms of completeness, consistency of format, clarity of concepts, usability, fit for purpose, performance, and reliability.
Guideline 4: Research Contributions –	DSR contributions include artefacts that add to the existing knowledge base or uses existing knowledge in innovative ways [12]. The contributions from this research include the use of existing knowledge in a novel way i.e. combined use of EMRAM (ability to define electronic medical record (EMR) capabilities in acute hospitals) and IT-CMF (ability to develop underlying IT organisational capabilities). Thus providing a unified and systematic view to planning, building and running Healthcare IT services via artefacts for healthcare organisations to determine their individual maturity levels, and identify improvement initiatives in a systematic manner. The HIT-MM defined, iterated and refined a suite of artefacts to facilitate combined usage of heretofore independently applied approaches into a repeatable format tailored to acute-care hospital environments.

Table 2. (*continued*)

Guideline 5: Research Rigor –	Rigor is derived from the effective use of the existing knowledge base to inform the research project [20], and includes existing theories, frameworks, artefacts, processes, methodologies, experiences and expertise within the application domain. The HIT-MM leverages the extensive base of industry and academic research that underpins IT-CMF and EMRAM in the field of IS management [21], and healthcare IT [22, 23]. Pragmatic validation of their combined use within the HIT-MM was applied on an iterative basis to continuously improve the artefacts developed and generate new ones. The research output of the HIT-MM provides artefacts to assist acute hospitals manage healthcare IT adoption in a more holistic and systematic manner – linking levels of targeted EMR technology implementations with prerequisite IT organisational capabilities to implement and effectively run those next levels of EMR.
Guideline 6: Design as a Search Process	DSR is conducted with knowledge of other, competing approaches and leverages a cyclical problem solving process, where solutions are evaluated against each other and against their efficacy for addressing the full problem under investigation. This build and evaluate loop is typically iterated a number of times before the final design of the artefact is completed [24]. The HIT-MM evaluated a number of potential management systems that advocating their relevance to IS management. The management systems of IT-CMF and EMRAM were selected due to their holistic approaches, academic underpinnings, industry backing and healthcare IT relevance – as outlined in earlier sections of this paper.
Guideline 7: Communication of Research -	Presentation of DSR artefacts should satisfy both academic rigour requirements and relevance requirements of the professional (e.g. managerial) audiences. This DSR work provides artefacts for acute-care hospitals to systematically improve planning for HIT adoption. IVI (an international consortium) is now the steward of these refined and new artefacts, which are available through IVI's education programmes to IS managers and researchers. Additionally, the HIT-MM supports CIO discussion of research outputs at professional conferences where Healthcare CIOs and IS practitioners can share perspectives and insights generated from the HIT-MM.

DSR has provided a useful research paradigm for the design and evaluation of HIT-MM - to research and validate novel artefacts that can address the problem of how acute-care healthcare organisations can systematically improve their planning for healthcare IT adoption. Using DSR activities, healthcare IS practitioners can more readily take advantage of these validated artefacts, as well as enabling researchers to contribute to the knowledge base for further extension, evaluation and establishment of better theories of understanding. Our research process follows the phases adapted for general design science research proposed by Vaishnavi and Kuechler [25] namely; problem awareness, suggestion, development, evaluation, and conclusion.

4 Healthcare Information Technology [HIT] Context and Research Problem

Porter and Millar [26] refer to information-intensity as to the information content of the service itself and the service within the value chain. In healthcare, patient information is not optional, it is essential and places high emphasis on how patient information is recorded; stored; accessed; distributed; and analysed (i.e. information-intensity), which in turn can have a contributory factor in patient outcomes [27,28]. For example, Holt et al [29] found that in an examination of over 1,800 surgeries, nearly a quarter were delayed due to missing or incomplete patient information.

Effective adoption of information technology in healthcare is associated with the improvement in the quality of care [30, 6] and reduction in costs [3], albeit sometimes within the context of wider healthcare reforms. The U.S. Department of Health and Human Services states:

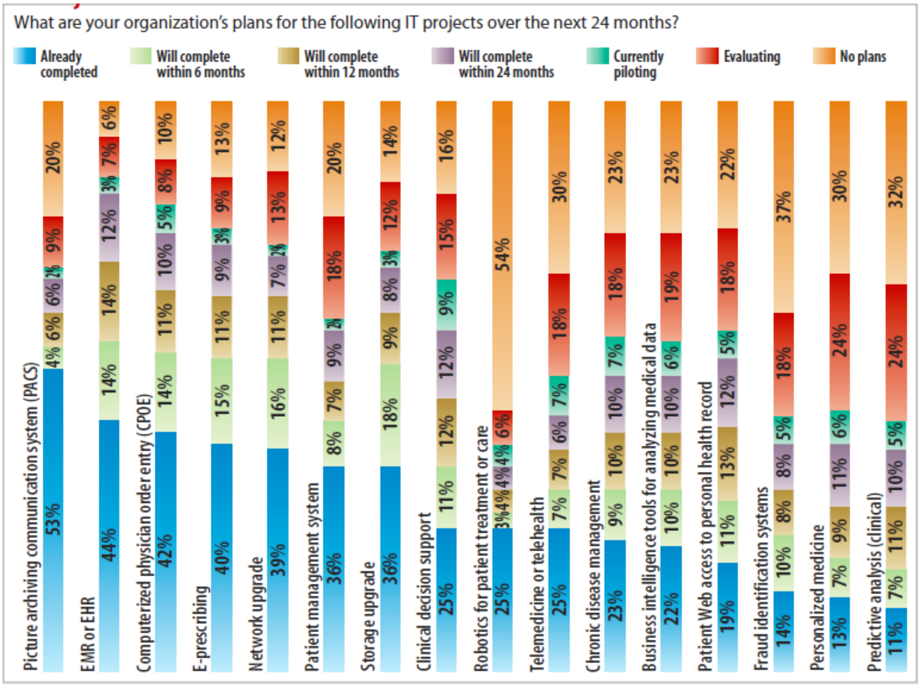
Health information technology [health IT] allows comprehensive management of medical information and its secure exchange between health care consumers and providers. Broad use of HIT has the potential to improve health care quality, prevent medical errors, increase the efficiency of care provision and reduce unnecessary health care costs, increase administrative efficiencies, decrease paperwork, expand access to affordable care, and improve population health [http://healthit.hhs.gov/].

Among the top issues of 170 North American CEOs and CIOs regarding prioritises in healthcare IT were; the implementation of electronic medical records (EMR), reducing healthcare errors with information technology and change management from paper to electronic medical records [31]. However, IT spending intensity in healthcare has traditionally lagged other industries that have similar levels of information-intensity. IDC [32] report the scale of healthcare IT spending in 2011 at $62BN, representing approximately 3.5% of the total $1.8TN IT expenditure globally. Similarly, analysis of Gartner [33] data suggests that relative IT expenditure per employee for healthcare ranges from approximately half to one-quarter of comparable information-intensive industries like Pharmaceuticals, Life Sciences & Medical Products and Banking & Financial Services respectively.

This gap may in-part be attributable to the recognition that implementation of IT in healthcare has been a continuous challenge [33, 35]. Hersh [36] points out:

Although the case for adoption of improved health care informatics appears quite compelling, significant barriers to its use remain …. These include cost, technical issues, system interoperability, concerns about privacy and confidentiality, and lack of a well-trained clinician informatics workforce to lead the process (p. 2273).

Additional contributory reasons affecting the complexity of healthcare IS adoption vis-à-vis other industries include; life and death nature of the subject, sensitivity of personal healthcare information, regulation, multidisciplinary and hierarchical nature of healthcare profession [28].



Base: 337 respondents working at a doctors' practice, hospital, healthcare center or other healthcare provider R4290312/3
Data: *InformationWeek* 2012 Healthcare IT Priorities Survey of 476 business technology professionals, January 2012

Fig. 1. Healthcare IT Priorities - Planned HIT Projects [Kolbasuk McGee, 2012]

While some advances have been achieved regarding healthcare IT adoption – there is still much to overcome. Figure 1 offers a snapshot of completion rates for HIT adoption and current gaps across North America Healthcare CIOs and IT practitioners, namely; picture arching (30% gap), and approximately 50% implementation gaps for electronic medical/health records, computerised physician order entry and e-prescribing. While this study focuses on HIT adoption in North American hospitals, it can serve as a useful a barometer and informs the authors' belief that other countries may be at best similar, if not lagging.

Insight into some of the contributing factors resulting in these implementation gaps is offered by a survey of 300+ healthcare practitioners [37]. The paper cites that after expense of implementation, the next most commonly cited barriers to adopting EMR or EHR were lack of confidence to run patient care and other processes uninterrupted while implementing new systems, lack of technical expertise within IT organization, and potential negative reaction to using new systems and processes from doctors and other clinicians. Furthermore, over 40% of these respondents had no plans to take advantage of emerging technologies like cloud computing that could be beneficial to quality of healthcare provision and reduction of costs.

While the opportunity is enormous for healthcare IT to positively impact the quality and cost of healthcare provision, the challenges to achieving this appear to be equally so.

5 Healthcare IT Maturity Model [HIT-MM] Overview

In response to this, Intel Corporation, Innovation Value Institute, HIMSS Analytics USA and HIMSS Analytics Europe have come together to create an industry leading model and programme for acute-care hospitals to enhance their IT organisational capabilities towards achieving better eHealth outcomes. The Healthcare IT Maturity Model (HIT-MM) is aimed at CIOs and senior IT decision-makers who are responsible for delivering and running clinical eHealth systems as well as more traditional IT systems. The results provide a solid foundation to trigger senior level decisions about improving constrained IT organisational capabilities considered essential for delivering and running better IS healthcare services.

The HIT-MM is administered under the HIT-MM programme to enable acute-care hospitals map the maturity of their healthcare IS services to the maturity of their underlying IT organisational and management capabilities to deliver and run those IS services. It aims to offer actionable insights through combining technology roadmaps for adopting a fully paperless electronic patient record environment – called EMR Adoption Model (EMRAM) [22], with roadmaps for improving underlying IT organisational capabilities - called the IT Capability Maturity Framework (IT-CMF) [38, 39].

A goal in researching and developing the HIT-MM was not to ‘reinvent the wheel’, rather identify potential complimentary but heretofore independently utilised approaches. EMRAM provides insights on the level of electronic medical record (EMR) capabilities in acute hospitals, with focus on technology implementation roadmaps to achieve increased levels of EMR and participation in an electronic health record (EHR), while IT-CMF focuses on managing underlying IT organisational capabilities that deliver and run clinical IS and general IS services.

The HIT-MM focused on developing Design Science Research (DSR) artefacts that enable the combined utilisation of EMRAM and IT-CMF approaches into a unified perspective. Its aim is to enable hospitals to respectively understand the next step of EMR technology implementation and in parallel close gaps in IT organisational capabilities to deliver and run better EMR and general IS services. The remainder of this section provides a summary overview of IT-CMF and EMRAM and artefacts for their combined approaches.

5.1 IT Capability Maturity Framework (IT-CMF)

The IT-CMF is a CIO and Senior IT management system that facilitates continuous performance improvement across the entire IT organization. IT-CMF is designed to reduce complexity by systematically addressing IT organizational capability gaps, via a toolset that contains maturity profiles, assessment methods and organizational improvement roadmaps; which collectively target improved delivery of value and innovation. The framework:

- Objectively identifies gaps in IT capabilities that are limiting IT performance and delivery of business value and innovation
- Contains standardized organizational assessment tools that allow organizations to benchmark themselves against similar organizations
- Defines a systematic structure to implement best practice improvements in IT performance and measure benefits over time

The origins of IT-CMF can be traced back to when Intel IT undertook a transformation to quantify and demonstrate the true value impact of IT. Professor Martin Curley, Vice President and Director of Intel Labs Europe, captured many of those approaches in his book [40], along with case studies from industry peers, which resulted in the IT Capability Maturity Framework (IT-CMF). Since then, the Innovation Value Institute (IVI) has been steadily developing this original work with further research on additional best practices, organizational assessment approaches and improvement roadmaps. The Innovation Value Institute (IVI) is a not-for-profit organisation, hosting an open-innovation international consortium across multiple industries and academic institutions. Collectively, they have extended the IT Capability Maturity Framework™ (ITCMF ™) into a cross-industry IT management best practice approach to assist public and private sector CIOs and senior IT decision-makers to systematically improve IT organisational capability gaps, allowing better management of IT.

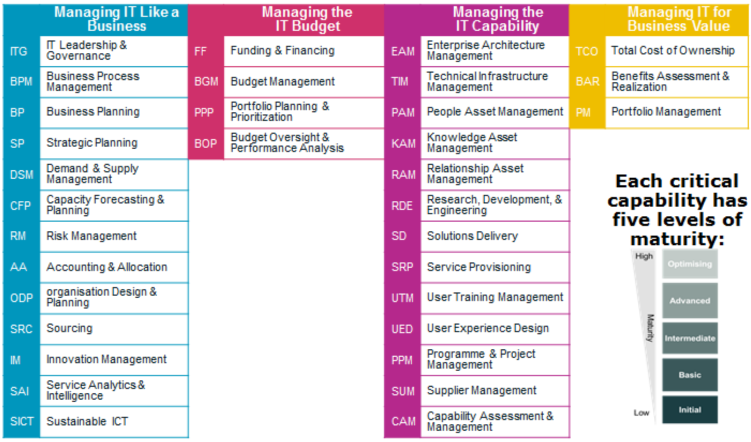


Fig. 2. IT-CMF's Critical Capabilities

The IT capability domain areas examined as part of the IT-CMF assessment are listed in Figure 2. IT-CMF's assessment methodology provides a heat-map of critical capability areas to target, together with recommended improvement roadmaps.

Utilising the IT-CMF as part of a continuous IT capability improvement programme is associated with improved IT performance including lower IT costs, and higher business value returns [40, 41, 42]. Furthermore the growing industry uptake of IT-CMF enabled via the IVI ecosystem can be a reasonable indicator of utility, with a recent IEEE article citing that IT-CMF "…shows all signs of being the industry standard for IT readiness and maturity measurement and improvement" [43].

The development of the IT CMF is underpinned by DSR approach which has been previously documented [39, 44, 45, 46], a brief summary is presented in the remainder of this sub-section.

While there already existed multiple fragmented IS management systems offering best practices and guidance in fragmented domain areas of IS management, they did not address in a holistic manner the full spectrum of IS challenges faced by CIOs and IS managers in managing an Enterprise IT organisation, or provide a value and innovation management perspective demanded by this audience. This formed the problem relevance for development of IT CMF to address this need. The theoretical underpinnings for IT-CMF approach are grounded in the field of IS literature and well debated Dynamic Capabilities [47]. Furthermore, the development of the IT-CMF draws from an extensive base of industry and academic literature including existing artefacts, methodologies, foundational theories, industry expertise and existing IS management approaches and frameworks. The use of this existing knowledge was leveraged by formal IVI working groups (staffed by subject matter experts drawn from academia and industry), which were overseen by a Technical Committee that used a multi-stage iterative research process to research and develop the IT-CMF. The outputs were a set DSR artefacts comprising of maturity curves (categorised as Models) and improvement practices (Methods), codified maturity assessments and library of maturity improvement practices (instantiations). These formed novel DSR artefacts that contribute to a continuous improvement management system for CIOs and IS manager to increasingly deliver optimised innovation and value from the IS organisation.

5.2 Electronic Medical Record (EMR™) Adoption Model™ (EMRAM)

HIMSS (Healthcare Information and Management Systems Society) Analytics is a non-for-profit entity positioned to be an authoritative source on EMR Adoption trends – providing data to facilitate improved decision making for healthcare organizations and policy makers. To track EMR progress at hospitals and health systems, HIMSS Analytics consulted with shared interest groups and steering committees – consisting of key health informatics and healthcare professionals – to devise the EMR Adoption Model (EMRAM). Development also included of testing the EMRAM model for suitability and individual refinement across various geographies to reflect local characteristics [48, 22].

HIMSS Analytics' Electronic Medical Record (EMR™) Adoption Model™ (EMRAM) identifies the levels of EMR capabilities ranging from the initial clinical data repository (CDR) environment through an EMR environment where paper charts are no longer used to delivery patient care – all care processes are supported with

EMR Adoption Model℠

Stage	Cumulative Capabilities
Stage 7	Complete EMR; CCD transactions to share data; Data warehousing; Data continuity with ED and ambulatory
Stage 6	Physician documentation (structured templates), full CDSS (variance & compliance), full R-PACS
Stage 5	Closed loop medication administration
Stage 4	CPOE, CDSS (clinical protocols)
Stage 3	Nursing/clinical documentation (flow sheets), CDSS (error checking), PACS available outside Radiology
Stage 2	CDR, Controlled Medical Vocabulary, CDS, may have Document Imaging, HIE capable
Stage 1	Ancillaries – lab, rad, pharmacy - all installed
Stage 0	All three ancillaries not installed

Fig. 3. HIMSS Analytics' Electronic Medical Record (EMR™) Adoption Model™ (EMRAM)

electronic documentation. EMRAM is an eight-stage model (Stages 0 to 7) that classifies an institution's level of IT adoption - refer to Figure 3.

HIMSS Analytics' methodology scores hospitals relative to their IT enabled clinical transformation status, providing peer comparisons for hospital organizations as they strategize their path to a complete electronic record management (EMR) and participation in an electronic health record (EHR). HIMSS Analytics collects and analyses international healthcare IT trends using this EMRAM method to score more than 5,300 healthcare providers throughout the US, Europe and Asia, resulting in a proven roadmap towards creating a paperless patient record environment for hospitals and health systems. Thus far, approximately 100 Stage 7 hospitals have been identified globally [www.himssanalytics.org website, last accessed Oct 2012]. A Stage 7 is a fully digitized, virtually paperless environment with a broad range of interoperability and data exchange capabilities with other organizations. Research data suggests that hospitals at a high level on the EMRAM model are more likely to demonstrate top performance on both; how patients are cared for through clinical measures and; how the hospital performs as an efficient business [22, 48].

5.3 Artefacts for an Unified Application of IT-CMF and EMRAM

As mentioned earlier, EMRAM provides insights to level of electronic medical record (EMR) capabilities in acute-care hospitals, with a focus on technology roadmaps to implement EMR and participation in an electronic health record (EHR). While IT-CMF focuses on managing underlying IT organisational capabilities to deliver and run IS clinical services. Independently, both approaches have widespread use by organisations. However, combining the complementary approaches of IT-CMF and EMRAM to provide a unified perspective allows hospitals to close gaps in IT organisational capabilities to deliver and run improved healthcare IS services – conceptually Figure 4 illustrates their complementary application and insights. In this illustration, a healthcare organisation has mapped its current level of EMR adoption at level 2 but is targeting EMR technologies of level 3 using the EMR Adoption Model (left-side of Figure 4). While the IT-CMF (right side of Figure 4) highlights underlying IT organisational capabilities considered necessary by the hospital's IS management team to assist with achieving the next level on EMR technology adoption.

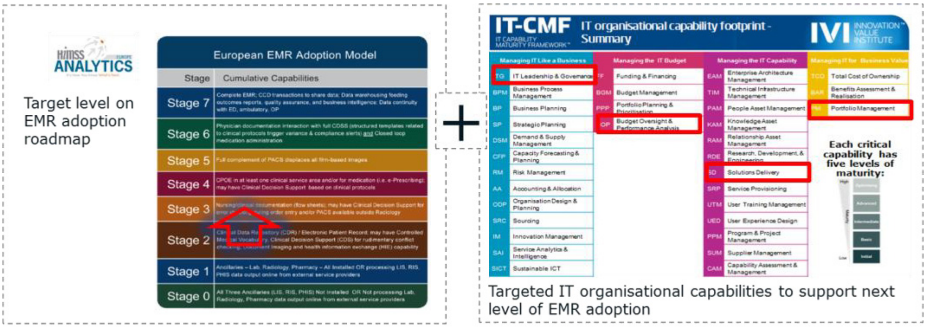


Fig. 4. Unified use of EMRAM and IT-CMF

Because both EMRAM and IT-CMF leverage maturity model architectures, and target discrete but related areas of information systems (IS) management (i.e. healthcare IT adoption and IT organisational capability respectively), there are considered highly complementary, i.e. they can highlight critical dependencies across targeted EMR levels and required IT organisational capabilities to achieve that level of EMR and general IS services. The unified application is designed to reveal constraining dependencies between desired levels of EMR adoption and underlying IT organisational capabilities, plus offer an improved and more systematic approach when planning outcomes from HIT investments.

5.4 Intel Healthcare Best-Practice Library

In addition to the unified usage of IT-CMF and EMRAM approaches, Intel Corporation provided healthcare IT adoption proof-points on emerging technologies such as mobile health, security, cloud and integrated care delivery. This additional layer allowed a hospital's IS management to consider how best to leverage emerging technologies that can enhance clinician IS services - via reference to a best-practice library of how other hospitals have overcome similar challenges and realised benefits.

6 HIT-MM Evaluation Process

A novel feature of this programme is evaluating the utility for combined used of IT-CMF and EMRAM - allowing for the cross-referencing of their respective insights - Figure 5 outlines a summary of the unified evaluation process. This instantiation represents novel evolution of the IT-CMF and EMRAM approaches for interoperability. The initial approach was designed and then refined through informed discussions with subject matter experts (SMEs) from respective frameworks and initial pilots with hospitals.

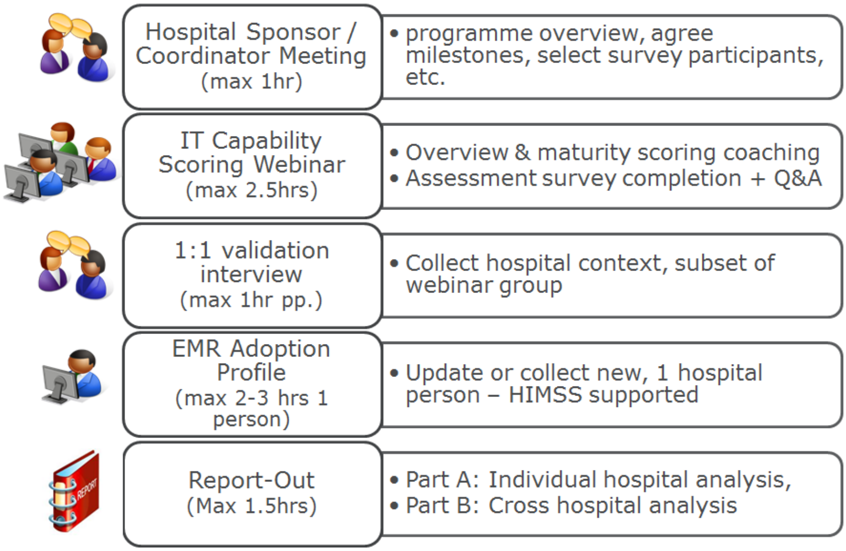


Fig. 5. HIT Maturity Model Process (Instantiation)

The first step in unified assessment was an orientation call with a sponsor at each hospital to agree objectives, benefits and milestones. This buy-in and support was crucial to the overall success of the HIT-MM programme. This was followed by a workshop (virtual, 2.5 hours) with the CIO/IT-Director plus selection of his/her staff to complete the IT Capability Maturity Framework (typically 4-8 participants). Participants completed questions individually after survey coaching while still on the webinar – with the facilitator available to assist with clarifications as they arise. Follow-up individual interviews (virtual, 1 hour) for a selected subset of workshop participants were conducted to augment additional insights with the IT-CMF data collected in the webinar. In parallel, the hospital completed (or updated) the Electronic Medical Record Adoption Model (virtual, typically 0.5-3 hours for one individual). Analysis of hospital's IT capability, and actionable improvement roadmaps were subsequently defined based on the collected data and presented in a two-phase report-out to hospitals.

The first phase of the report-out included analysis and recommendations for the hospital's IS strategy when planning investments in EMR technology adoption. Figure 6 illustrates one of the HIT-MM's artefacts - objectively prioritises IT capabilities to provide a quick and easy reference point for hospital's IS management to level-set on decisions about where improvements will be most effective. This and other artefacts allowed IS management to understand how the maturity of their healthcare EMR services is influenced by the maturity of their underlying IT organisational capabilities to deliver and run those services.

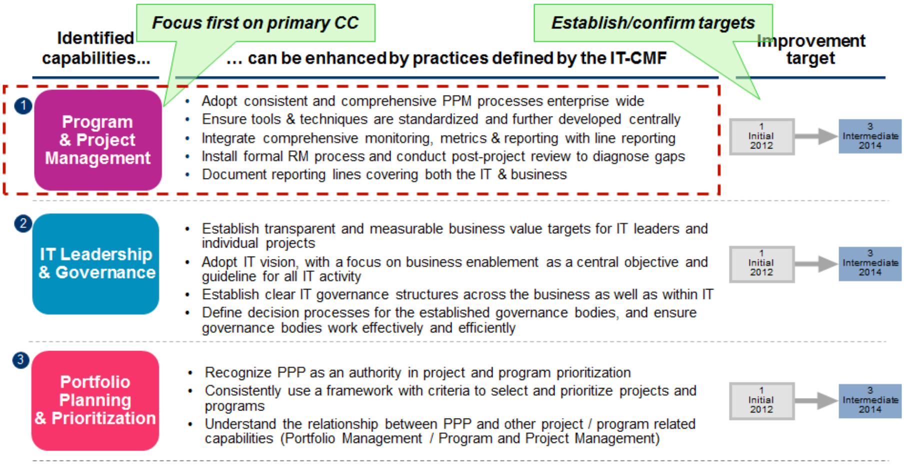


Fig. 6. IT-CMF Prioritisation (Artefact)

Figure 8 illustration relates to a phase-two report-out i.e. cross hospital mapping of EMR adoption levels to corresponding IT organisational capabilities - to discover the essential IT organisational capabilities that make certain hospitals more successful in EMR adoption over others. These comparative insights draw from cross-hospital analysis following a valid cohort of hospitals assessed as part of the HIT-MM.

Figure 7 is illustrates recommendations from the IT-CMF on how to address prioritised IT capabilities (i.e. execute stable and repeatable patterns of IT management activities) that will make a difference to eHealth adoption. These best-practice guidance are drawn from IT-CMF artefacts and enhanced for target audience where necessary.

Figure 8 illustration relates to a phase-two report-out i.e. cross hospital mapping of EMR adoption levels to corresponding IT organisational capabilities - to discover the essential IT organisational capabilities that make certain hospitals more successful in EMR adoption over others. These comparative insights draw from cross-hospital analysis following a valid cohort of hospitals assessed as part of the HIT-MM.

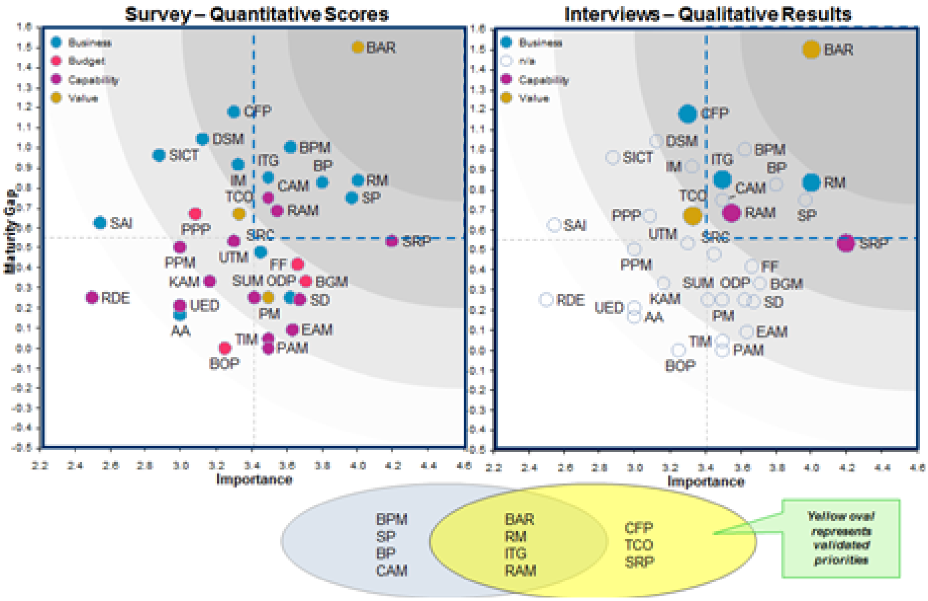


Fig. 7. IT-CMF Recommendation (Artefact)

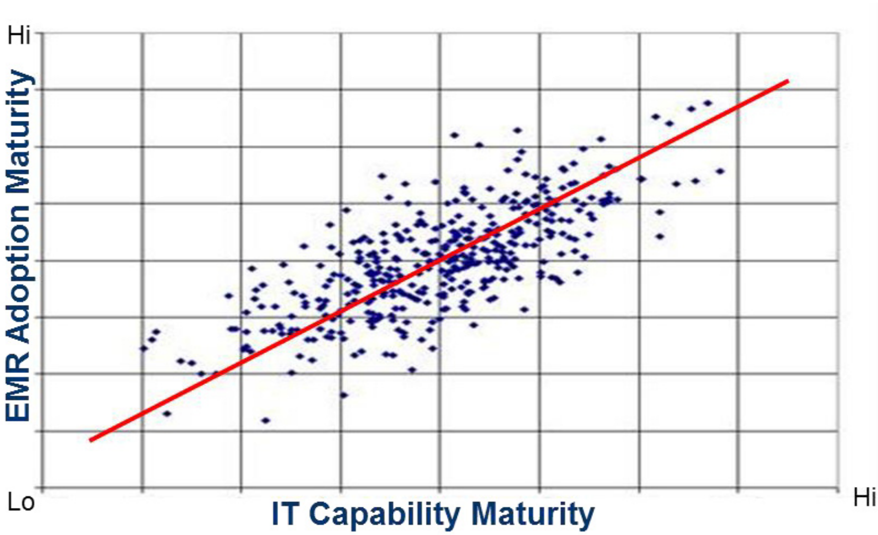


Fig. 8. IT-CMF and EMRAM Combined Approaches (Model)

This analysis will provide predictive insights on required IT capabilities to achieve next level of EMR adoption. It allows individual hospitals infer comparative insights from peer hospitals that may be further along the EMR adoption roadmap.

To date, 16 hospitals have participated in this programme – predominantly located in Europe and a smaller number in North America. Approximately 30% of hospitals had achieved EMRAM stage 6 or better and greater than 30% were larger than 500 beds. The nascent patterns suggest that hospitals who are lower on EMR adoption typically prioritise more technical and traditional service orientated critical capabilities of the IT-CMF. Whereas, hospitals higher on EMR adoption typically focus on more business orientated critical capabilities. Intuitively, this is reasonable pattern to expect, as at lower levels of EMR adoption – the focus is more on implementation and running of discrete (often considered 'back-of-house' or platform) healthcare systems. Whereas at higher EMR adoption levels, the focus moves to more proactive stakeholder and change management, as cross-system integration and point-of-care systems become more prevalent [48, 22]. This analysis offers practical insight to hospitals who are seeking to progress their levels of EMR adoption and want to understand prerequisite IT capabilities they should also develop to ensure success.

Intel Corporation, Innovation Value Institute and HIMSS Analytics have supported a series of international CIO workshops to communicate and discuss the research outputs, principally; HIMSS Annual Conference & Exhibition 2012 (Las Vegas), eHealth Week 2012 (Copenhagen) and HIMSS CIO Leadership Conference 2012 (Mallorca). The artefacts of HIT-MM have been adopted by IVI into its professional education and training curriculum for CIOs and IS managers. These activities facilitate communication of research insights to professional and academia – plus offer invitations for other hospitals to benefit from participation. Furthermore, HIT-MM programme stakeholders are committed to a series of publications targeting the healthcare industry and academia.

7 Summary and Conclusion

Design-science research (DSR) goal is to overcome challenges in unique or innovative ways or in more effective or efficient ways. Hevner et al (2004) state the "design is essentially a search process to discover an effective solution to a problem" without the necessary need to explicitly specify all possible solutions. DSR seeks to establish the utility of artefacts and to characterize the environments in which it works, even if it cannot be completely explained why it works. Using this view, the design and evaluation of the Healthcare IT Maturity Model (HIT-MM) process and its artefacts –described in previous sections – can be characterised as design science orientated.

In this paper the authors describe the rationale for a combined approach to using IT-CMF and EMRAM (under the umbrella of the HIT Maturity Model) towards increasing effective adoption of Healthcare IT. The paper briefly describes the design science research approach of the HIT-MM. The objective of HIT-MM is to enable hospitals to more systematically strategize their adoption of the next level of HIT systems, and in parallel determine what IT organisational capabilities are needed to support those activities. There is however more research needed, in particular validating the emerging patterns and trends over a larger population and multiple time periods, as well as understanding potential variances that may be attributable due to differences in national and regional healthcare policies.

Acknowledgments. The authors express their gratitude towards participating hospitals for their collaboration and support of this programme research. The authors would also like to thank Professor Brian Donnellan (NUI Maynooth) for his suggested readings.

References

1. OECD, OECD report issued (June 30, 2011), `http://www.oecd.org/health/healthdata`
2. Romanow, D., Cho, S., Straub, D.W.: Riding the Wave: Past Trends and Future Directions for Health IT Research. MIS Quarterly 36(3), iii–x (2012)
3. Chaudhry, B., Wang, J., Wu, S., Maglione, M., Mojica, W., Roth, E., Morton, S.C., Shekelle, P.G.: Systematic Review: Impact of Health Information Technology on Quality, Efficiency, and Costs of Medical Care. Annals of Internal Medicine 144, E-12–E-22 (2006)
4. Koshy, R.: Navigating the Information Technology Highway: Computer Solutions to Reduce Errors and Enhance Patient Safety. Transfusion 45, 189S–205S (2005)
5. Kutney-Lee, A., Kelly, D.: The Effect of Hospital Electronic Health Record Adoption on Nurse-assessed Quality of Care and Patient Safety. Journal of Nursing Administration 41(11), 66–72 (2011)
6. Buntin, M.B., Burke, M.F., Hoaglin, M.C., Blumenthal, D.: The Benefits of Health Information Technology: A Review of The Recent Literature Shows Predominantly Positive Results. Health Affairs 30, 3464–3471 (2011)
7. Jha, A.K., DesRoches, C.M., Campbell, E.G., Donelan, K., Rao, S.R., Ferris, T.G., et al.: Use of electronic health records in US hospitals. New England Journal of Medicine 360(16), 1628–1638 (2009)
8. Blumenthal, D.: Launching HITECT. New England Medical Journal, 382–385 (2010)
9. Brynjolfsson, E., Hitt, L.M.: Beyond the productivity paradox. Communications of the ACM 41(8), 49–55 (1998)
10. Agarwal, R., Gao, G., DesRoches, C., Jha, A.K.: Research Commentary — The Digital Transformation of Healthcare: Current Status and the Road Ahead. Information Systems Research 21(4), 796–809 (2010)
11. Hevner, A., Chatterjee, S.: Design Science Research in Information Systems. Springer Science and Business Media (2010)
12. Hevner, March, S., Park, J., Ram, S.: Design Science Research in Information Systems. Management Information Systems Quarterly 28(1), 75–105 (2004)
13. Simon, H.: The Sciences of Artificial, 3rd edn. MIT Press, Cambridge (1996)
14. March, S.T., Smith, G.F.: Design and natural science research on information technology. Decision Support Systems 15, 251–266 (1995)
15. Rossi, M., Sein, M.: Design Research Workshop: A Proactive Research Approach. Presentation delivered at IRIS 26, August 9-12 (2003)
16. Purao, S.: Design Research in the Technology of Information Systems: Truth or Dare. GSU Department of CIS Working Paper, Atlanta (2002)
17. March, S.T., Storey, V.C.: Design Science in the Information Systems discipline: an introduction to the special issue on design science research. MIS Quarterly 32(4), 725–730 (2008)
18. Sambamurthy, V., Zmud, R.W.: Research Commentary: The Organizing Logic for an Enterprise's IT activities in the Digital Era – A Prognosis of Practice and a call for Research. Information Systems Research 11(2) (June 2000)

19. Benbasat, I., Zmud, R.W.: Empirical research in information Systems: the practice of relevance. MIS Quarterly 23(1), 3–16 (1999)
20. Hevner, A.: A three-cycle view of design science research. Scandinavian Journal of Information Systems 19(2), 87–92 (2007)
21. Curley, M., Kenneally, J.: Using the IT Capability Maturity Framework to Improve IT Capability and Value Creation: An Intel IT Case Study. In: 15th IEEE International Enterprise Distributed Object Computing Conference, Conference Proceedings, pp. 107–115 (2011)
22. HIMSS Analytics, "Electronic Medical Record Management – EMRAM" (2012), http://www.himssanalytics.org/emram/index.aspx (last accessed October 2012)
23. HIMSS ANALYTICS, "Quality and Safety Linked to Advanced Information Technology Enabled Processes" (April 2012)
24. Markus, M.L., Majchrzak, A., Gasser, L.: A Design Theory for Systems that Support Emergent Knowledge processes. MIS Quarterly 26(3), 179–212 (2002)
25. Vaishnavi, V., Kuechler, W.: Design Research in Information Systems (2004/2005), http://www.isworld.org/Researchdesign/drisISworld.htm (last accessed October 2012)
26. Porter, M.E., Millar, V.A.: How Information Gives You Competitive Advantage. Harvard Business Review 73(4) (July-August 1985)
27. Lahiri, A., Seidmann, A.: Information Hang-overs in Healthcare Service Systems. MSOM Fall 14, 634–653 (2012); Published online before print (April 13, 2012)
28. Fichman, R.G., Kohli, R., Krishnan, R.: The Role of Information Systems in Healthcare: Current Research and Future Trends. Journal Information Systems Research 22(3), 419–428 (2011)
29. Holt, N.F., Silverman, D.G., Prasad, R., Dziura, J., Ruskin, K.J.: Pre-anesthesia clinics, information management, and operating room delays: results of a survey of practicing anesthesiologists. Anesthesia and Analgesia 104(3), 615–618 (2007)
30. Bates, D.W., Ebell, M., Gotlieb, E., Zapp, J., Mullins, H.C.: A Proposal for Electronic Medical Records in U.S. Primary Care. Journal of the American Medical Informatics Association 10(1), 1–10 (2003)
31. Palvia, P., Lowe, K., Nemati, H., Jacks, T.: Information Technology Issues in Healthcare: Hospital CEO and CIO Perspectives. Communications of the Association for Information Systems 30, Article 19 (2012)
32. IDC, "IDC's Worldwide IT Spending Patterns: The Worldwide Black Book 2011" (2011), http://www.idc.com/getdoc.jsp?containerId=IDC_P336 (last accessed October 2012)
33. Gartner, "IT Key Metrics Database" (2011), http://my.gartner.com/portal/server.pt?open=512&objID=260&mode=2&PageID=3460702&id=1495114&ref=clientFriendlyUrl (last accessed October 2012)
34. Hagland, M.: Clinical Is King: This Year's HIMSS CIO Survey Found That Using Clinical IT to Improve Patient Safety Was Top-of-mind. Healthcare Informatics 24(6), 16–17 (2007)
35. Angst, C.M., Aggarwal, R.: Adoption of Electronic Health Records in the Presence of Privacy Concerns: The Elaboration Likelihood Model and Individual Persuasion. MIS Quarterly 33(2), 339–370 (2009)
36. Hersh, E.: Health Care Information Technology: Progress and Barriers. JAMA 292, 2273–2274 (2004)

37. Kolbasuk McGee, M.: Healthcare IT Priorities Survey of business technology professionals (2012), http://reports.informationweek.com/abstract/105/8692/healthcare/research-healthcare-it-2012-priorities-survey.html (last accessed October 2012)
38. Curley, M.: Introducing an IT Capability Maturity Framework. In: Cardos, J., Cordeiro, J., Filipe, J. (eds.) ICEIS 2007. LNBIP, vol. 12, pp. 63–78. Springer, Heidelberg (2007)
39. Curley, M., Kenneally, J., Dreischmeier, R.: Creating a New IT Management Framework Using Design Science: A Rationale for Action and for Using Design Science. In: Helfert, M., Donnellan, B. (eds.) EDSS 2011. CCIS, vol. 286, pp. 96–115. Springer, Heidelberg (2012)
40. Curley, M.: Managing Information Technology for Business Value. Intel Press (January 2004)
41. Curley, M.: The IT transformation at Intel. MIS Quarterly Executive 5(4(1)), 109–122 (2006)
42. Curley, M., Kenneally, J.: Methods and Metrics to improve the Yield of IT using the IT-CMF - An Intel Case Study. In: Proceedings IEEE Equity (2009)
43. Costello, T.: A New Management Framework for IT. IT Professional 12(6), 61–64 (2010), doi:10.1109/MITP.2010.142
44. Carcary, M.: Design Science Research: The Case of the IT Capability Maturity Framework (IT CMF). The Electronic Journal of Business Research Methods 9(2), 109–118 (2011)
45. Donnellan, B., Helfert, M.: The IT CMF: A Practical Application of Design Science. In: Winter, R., Zhao, J.L., Aier, S. (eds.) DESRIST 2010. LNCS, vol. 6105, pp. 550–553. Springer, Heidelberg (2010)
46. Helfert, M., Curley, M.: Design Science in Action: Researching and Developing the IT-CMF. In: Helfert, M., Donnellan, B. (eds.) EDSS 2011. CCIS, vol. 286, pp. 50–59. Springer, Heidelberg (2012)
47. Teece, D.J., Pisano, G., Shuen, A.: Dynamic Capabilities and Strategic Management. Strategic Management Journal 18(7), 509–533 (1997)
48. HIMSS ANALYTICS, "EMR Sophistication Correlates to Hospital Quality Data" (2006)

The DRIVES (Design Research for Innovation Value, Evaluation, and Sustainability) Model of Innovation

Alan R. Hevner[1], Brian Donnellan[2], and Jack Anderson[3]

[1] University of South Florida
ahevner@usf.edu
[2] National University of Ireland Maynooth
brian.donnellan@nuim.ie
[3] Chevron Corporation
jack.anderson@chevron.com

Abstract. We propose a new innovation model that leverages Design Science Research concepts and principles. The goal of this paper is to outline the six stages of DRIVES with brief descriptions of the activities performed during the stages. An industrial consortium provides some observations on the application of DRIVES for innovation.

Keywords: Design Science Research, Innovation, Information and Communications Technologies and Systems.

1 Introduction

The synergistic relationship between widely used innovation processes, such as IDEO [8] and the Design Science Research (DSR) paradigm [7] has been identified and explored. In Anderson et al. [1], we use a real-life case study of an IDEO-based Innovation Cycle in Chevron to perform a gap-analysis with DSR. The results of the study suggest that there are key insights that can be drawn from the DSR concepts and guidelines that can potentially impact and improve organizational innovation processes. Based on our initial gap analysis, we find five key areas of potential DSR contribution.

1.1 Artifacts

The Innovation literature focuses on the contribution of the artifact to the application environment and the 'adopting unit.' The case study indicates that innovative artifacts can take on many forms of abstract knowledge (e.g. models, architectures, methods), as well as, physical or systems-based instantiations. Current innovation processes, as exemplified by the application of the IDEO innovation approach in Chevron, focus on the outcome of the overall process rather than the artifacts that are created at each stage of the process. The identification and analysis of artifacts created throughout the entire innovation process may well be a core differentiator between DSR and Innovation.

M. Helfert and B. Donnellan (Eds.): EDSS 2012, CCIS 388, pp. 144–154, 2013.
© Springer International Publishing Switzerland 2013

1.2 The Central Role of Evaluation

DSR guidelines stress the importance of evaluation of utility, quality, and efficacy. Apart from an effort by Venkatesh and Davis [13] to establish evaluation criteria for disruptive innovations, there is little evidence of extensive use of evaluation methods in the innovation process. It is not well defined how innovators appropriately select evaluation methods to provide convincing evidence of their artifact's utility and qualities. We posit that the emphasis on evaluation in DSR could have great potential to inform innovation processes.

1.3 Rigor

DSR guidelines stress the application of rigor in the development process – as a means of enhancing the quality of the artifact that emerges from the process. A corresponding emphasis on rigor in construction and evaluation is not to be found in the Innovation literature. We would argue that rigor in innovation processes is just as essential as in DSR. Attention to the most appropriate and effective techniques for building and evaluating the innovation is critical to an innovation's acceptance and success in the market place.

1.4 Search

In the case study, only contributions that are new and unique to the group executing the Innovation Challenge are in focus, so there is an onus on members of the innovation community to perform relevant searches. While we found a number of similarities between the search processes for design artifacts in DSR and the Chevron innovation process, we believe that further study is needed to fully understand the relationships between the methods for searching complex solution spaces for innovations and design solutions.

1.5 Contributions and Value

DSR guidelines stress that clear and verifiable contributions in the areas of the design artifact, design theories, and/or design methodologies are required. In parallel the innovation cycle stresses the drive for solutions that are new, value-added contributions to the organization applying them. The case study looked at the value of artifacts throughout the innovation cycle which lead to important findings that are useful to business, as understanding the business value of the innovation process is one of the major problems facing organizations today. As established innovation processes do not usually analyze the value of all ideas (usually only ideas that pass final approval at the end of the process are analyzed for value) our analysis led us to interesting discoveries of potential value of artifacts throughout the cycle.

2 The DRIVES Model of Innovation

Drawing from this gap analysis of Design Science Research and the Chevron Innovation Cycle, we propose a DSR influenced innovation model termed DRIVES

(Design Research for Innovation Value, Evaluation, and Sustainability). The application of DSR concepts and guidelines to the discovery and development of innovative artifacts can be described in the following six-stage innovation model.

2.1 Challenge

Define and describe the challenge to be addressed by the Innovation Process. This stage elicits the essential requirements information for the desired innovation and structures the innovation task for subsequent stages of DRIVES.

a. Use appropriate techniques and models to formulate state representations of the current environment and the goal environment.
b. Expose the problem or opportunity to be addressed by the desired innovation. How would the innovation transform the current state to the goal state?
c. Describe the *Design Space* via parameters that can be manipulated by heuristic search algorithms. The design space can be viewed as the collection of all possible designs and requirements. Conceptually, then, we can imagine that the space is partitioned between a few known and many unknown designs. The design process begins with a search of this space in order to identify one or more particular positions, which can be referred to as *Design Candidates*.
d. The search for high fitness design candidates and artifacts requires utilizing available means to reach desired ends while satisfying laws in the design space.
e. The principle issue in this stage is *Complexity*. Any real-world problem or opportunity will necessarily be embedded in a complex environment making its solution a *wicked problem*.
f. Designers may react to complexity in the innovation process in many different ways. They may choose to decompose the problem into sub problems, each of which then becomes the basis of its own task. They may choose to approach the problem iteratively, using the repetitive build-evaluate cycles that are typical of agile programming. They may choose to reframe the problem entirely, perhaps using analogy to look at the problem in an entirely different way.

2.2 Ideation

The goal in this stage is to search the design space and generate feasible candidate designs. The essence of this stage is *Creativity* to produce novel ideas in the form of artifacts.

a. In the early stages of design discovery each new artifact is "an experiment" that "poses a question to nature" [10 p. 114]. Existing knowledge is used where appropriate to build the artifact; however, most often the requisite knowledge is nonexistent. As previously noted, such artifacts may be symbolic or physical representations of our selected location in the design space
b. *Providing evidence of design feasibility* - Can the proposed design be implemented and does the proposed design meet the requirements? Building feasibility artifacts moves designs across the unknown/known partition.

c. This stage can be compared to the traditional ‘brainstorming’ phase of innovation. However, our concept of ideation is more constrained by the activities of the previous ‘challenge’ stage. Candidate designs, e.g. ideas, must provide evidence of feasibility before acceptance.

2.3 Refinement

This stage contains the core ‘build – evaluate’ design cycle of Design Science Research. Feasible candidate designs are refined during rigorous cycles of building out the design artifact and subjecting it to appropriate evaluation methods that demonstrate its strengths and weaknesses to achieve the goal state.

a. The internal design cycle is the heart of any DSR project. This cycle of research activities iterates rapidly between the construction of an artifact, its evaluation, and subsequent feedback to refine the design further. Simon [12] describes the nature of this cycle as generating design alternatives and evaluating the alternatives against requirements until a satisfactory design is achieved. The design cycle is where the hard work of DSR is done. During the performance of the design cycle a balance must be maintained between the efforts spent in constructing and evaluating the evolving design artifact. Both activities must be convincingly based in relevance and rigor. Artifacts must be rigorously and thoroughly tested in laboratory and experimental situations before releasing the artifact into use. This calls for multiple iterations of the design cycle before contributions are identified in the next stage.
b. Successful innovation also requires the intellectual *Control* to refine creative thinking into practical solutions. Such control is dependent on the cognitive skills of reason and judgment. In essence, maintaining intellectual control of the evolving Build activities in DSR results in the reduction of uncertainty. Drawing from ideas of problem structuring and complexity, we identify two types of uncertainty. A major challenge in problem structuring is differentiating between these two situations and then applying the most effective controls in order to refine the selected design candidates to use artifacts.
    i. Reducible Uncertainty – The problem can be decomposed into sub-problems that can be addressed independently via control techniques of learning, planning, abstraction, solution specification, and composition of solutions.
    ii. Irreducible Uncertainty – The problem has no clear decomposition and must be solved as a whole via control techniques like scenario generation and risk management.
c. The process of design refinement asks the following key Build questions:
    i. *Providing evidence of the value of the design* - Does the design offer benefits unmatched by competing design candidates? Here the objective becomes to establish an ordinal valuation that can be used to rank candidate designs.
    ii. *Determining the most effective representation of the design* – How can we best communicate the intricacies of the design to the implementers (e.g. architects, programmers).

iii. *Constructing the actual use artifacts* – How do we guide the construction of the use artifact? As examples - a blueprint is a construction artifact that serves to guide the physical construction of a house; source code is a construction artifact that serves to generate the programs that are distributed to users.

d. At the conclusion of this stage, there should exist only a very few surviving design candidates that will move onward to use in the target field environment.

2.4 Contribution

Once the refinement stage generates an innovative design artifact, a time of reflection is needed to understand how the new design contributes to the human knowledge base. Such reflection is extremely valuable during innovation to appreciate how truly innovative the ideas are or whether we are simply reinventing wheels.

a. Contributing to human knowledge is seen as the key criterion for the credibility of the innovation effort. The appropriate and effective consumption and production of knowledge are fundamental issues that innovation teams should consider throughout the innovation process – from initial problem selection, to the use of sound research methods, to reflection, and to communication of research results in journal and conference articles. The potential impacts of rigorous DSR are lost or marginalized when knowledge contributions are inadequately positioned and presented.
b. IT artifact plays a key role in knowledge contribution. In general, the term artifact refers to a thing that has, or can be transformed into, a material existence as an artificially made object (e.g., model, instantiation) or process (e.g., method, software). Many IT artifacts have some degree of abstraction but can be readily converted to a material existence; for example, an algorithm converted to operational software. In contrast, a theory is more abstract, has a non-material existence, and contains knowledge additional to the description of a materially existing artifact. The construction of an artifact and its description in terms of DSR concepts and principles can be seen as steps in the process of developing more comprehensive bodies of knowledge or design theories.
c. A DSR Knowledge Contribution Framework as presented by Gregor and Hevner [5] posit a DSR knowledge contribution framework as an effective way to understand and position a DSR project's research contributions. Clearly identifying a knowledge contribution is often difficult in DSR because it depends on the nature of the designed artifact, the state of the field of knowledge, the audience to whom it is to be communicated, and the publication outlet. In addition, the degree of knowledge contribution can vary: there might be incremental artifact construction or only partial theory building, but this may still be a significant and publishable contribution. The size of the knowledge increase could be offset by the practical impact in a knowledge area.

2.5 Use

The goal in this stage is to actualize the candidate artifacts via prototyping or other forms of implementation and study in the target environment. Field evaluations are performed to understand the utility and fitness of the artifact in context.

a. The output from the previous stages must be returned into the environment for study and evaluation in the application domain. The field study of the artifact can be executed by means of appropriate technology transfer methods such as action research [11].
b. The results of the field testing will determine whether additional iterations of the refinement stage are needed. The new artifact may have deficiencies in functionality or in its inherent qualities (e.g., performance, usability) that may limit its utility in practice. Another result of field testing may be that the requirements input to the innovation process were incorrect or incomplete with the resulting artifact satisfying the requirements but still inadequate to the opportunity or problem presented. Returning to the Challenge stage will commence with feedback from the environment from field testing and a restatement of the research requirements as discovered from actual experience.
c. The use artifacts are divided between pilot test instances—for which returning to the design cycle of refinement is intentionally left open as a possibility—and release use instances, for which further redesign is not immediately anticipated. While this conceptual scheme obviously maps directly to IT artifacts such as software, it should be recognized that organizations frequently employ a phased roll out of non-technology artifacts, such as organizational structures or incentive plans, with the same notion that the design may later be tuned based upon early experience.
d. The results of this stage will indicate whether the proposed artifact is a satisfactory result of the innovation process or whether the process will need to return to a previous stage for more work.

2.6 Sustainability

The final stage of the innovation process moves beyond the current usefulness of the design artifact to a fuller appreciation of the sustainable value of the innovation. Here we briefly discuss several characteristics of a sustainable innovation. The appropriate selection of sustainability criteria will depend on the innovation environment and goals.

a. Decomposibility - The seminal work that launched the study of design science is Herbert Simon's [12] *The Sciences of the Artificial*. The second half of the book is largely devoted to explaining why systems tend to evolve from nearly decomposable subsystems. Indeed, even under the existing DSR goals, decomposability is likely to exert a strong influence on design quality and would therefore be evaluated as part of the design. In addition, such systems tend to be easier to construct, since work on individual components can be conducted separately.

b. Malleability - Often enhanced by decomposability, the malleability of an artifact represents the degree to which it can be adapted by its users and respond to changing use/market environments [6]. MIS research has demonstrated that users frequently employ tools for unintended purposes. We would expect that such adaptation would allow designers to evolve artifacts to support these uses more effectively. Tools such as scripting languages are sometimes incorporated into application designs to provide power user-malleability. User-malleability itself can be divided into levels, such as customization, integration and extension. Here customization refers to the ability of a design to be tailored to a user's preferences. Integration involves the ability to conveniently share the capabilities of one artifact with another, creating a resultant artifact with capabilities beyond those of either original design. The ability to create mash-ups of web components on a single page is an example of this capability. Extension means adding new capabilities to an artifact.
c. Openness - Another design characteristic that has the potential to impact design fitness is the degree to which artifacts are open to inspection, modification, and reuse. Open designs—particularly when combined with decomposability and malleability—encourage further design evolution by making it easier both to see how an artifact is constructed and to modify existing components of the artifact. For example, an information system created as an open source application has a significant advantage over a proprietary design in terms of its ability to evolve rapidly.
d. Embeddedness in a Design System - We would expect design artifacts that are the product of a sustainable design system environment to evolve more rapidly than artifacts that are produced in a context where design is an unusual activity. This particular source of fitness can sometimes act as a counterweight to openness, as organizations with highly effective research and development activities may be reluctant to open up their designs and may use legal measures—such as patents and copyrights—to discourage unauthorized parties from evolving the original designs. A design system can also manifest itself as a community of users and designers, providing contributors with intrinsic motivation to contribute.
e. Novelty - A design may be considered novel if it originates from an entirely new region of the design space. Once such a design candidate has proven viable, other design candidates from the same region are likely to follow in an attempt to locate the local peak on the fitness landscape. A particular challenge that novel design artifacts present is that the creative process through which they are envisioned may not meet the criterion of usefulness and rigor suggested by the original guideline and the potential benefits of the design may be hard to evaluate. A genuine new invention is a difficult goal for DSR research projects and we can expect few research contributions to be true inventions [5]. However, exploration for new ideas and artifacts should be encouraged regardless of the hurdles.
f. Interestingness - Normally, a design artifact is created in order to explore or demonstrate some specific purpose. From time-to-time, however, an artifact may demonstrate unexpected emergent behaviors that are worthy of subsequent investigation and the creation of subsequent artifacts. An artifact may also be

constructed in an unexpected way that intrigues other designers or design researchers. We characterize such designs as *interesting*. While there is likely to be considerable overlap between designs that are interesting and designs that are novel, the two characteristics are not identical. We have framed the benefits of novelty in terms of contributing to the diversity of the design landscape. Broadly speaking, the benefit of an interesting design is its propensity to diffuse. In fact, requiring a design to be interesting may serve as a limitation on its novelty.

g. Elegance - In many areas of design, such as architecture, consumer products and apparel, there is an ongoing tension described as form versus function. Function relates to practical usefulness. Form, in contrast, describes aesthetic elements such as appearance that do not necessarily serve a useful purpose, yet nevertheless increase the user's utility. The characteristic of an IS design artifact that corresponds to form might best be referred to as *elegance*. Like quality, elegance is hard to define in a rigorous manner and yet characteristics that might be associated with it—such as compactness, simplicity, transparency of use, transparency of behavior, clarity of representation—can all lead to designs that invite surprise, delight, imitation, and enhancement. Equally important, they can cause a design artifact whose usefulness has yet to be demonstrated to endure.

3 Observations and Future Directions

Current methods of innovation, such as IDEO, are being criticized for a lack of rigor and 'scientific' results in their execution [4]. Our goal in this paper is to propose the DRIVES model of innovation that incorporates the rigor of Design Science Research into an innovation process. In this concluding section, we provide observations of an industrial consortium to the DRIVES model.

During 2012, a consortium of innovation leaders from four major corporations conducted an analysis of innovation processes and methods. This Innovation Management Research (IMR) Group participated in a research project on the measurement of innovation management processes. The four corporations represented in the group leverage a similar framework for innovation based on the well-known IDEO innovation cycle. The IMR group also leveraged research and lessons learned from participation in the Innovation Management Working Group of IVI (Innovation Value Institute). In their initial exposure to the DRIVES model, they identified two significant areas that are considered ripe for benefit from DSR concepts: the Challenge Stage and the Refinement Stage. Thus, the following analysis focuses on observations from these two areas.

3.1 Challenge Stage Observations

The DRIVES model Challenge Stage maps to the first two steps in the IDEO Innovation Cycle: Understand and Observe. The goals of these steps are to secure an understanding of the challenge at hand, to develop artifacts that are used to enable participants to understand the problem so that they can contribute new ideas to the solution of the problem or challenge, and to develop metrics to measure the success of the effort.

The set of common tools utilized by the IMR Group to understand the **current environment** in innovation workshops include:

- Forcing factor analysis
- Root Cause Analysis
- Interviews of people involved in the current state
- Capability Assessment -- current state
- Organization metrics
- Project Look-Backs and Postmortems
- Value Stream Mapping
- Problem Statistics
- Success Statistics
- Technology review
- Pain point identification
- Benchmarking analysis of peer organizations – current state

Tools to identify the **goal environment** include:

- Vision statement – (example new market expansion)
- Benchmarking Analysis of peer organizations – desired/future state
- Capability assessment – future/desired state
- Best method Analysis
- Interviews of people involved in the current environment

Once the current environment and the goal environment are captured, the question of how the innovation would transform the current state to the goal state must be answered. This statement hits an important area of potential value of DSR to innovation. This is an area where the IMR Group observes that the art of creative thinking is leveraged rather than having a methodical practice that can measured. At this stage the option is usually done by "Connectors" as described by the IMR Group: people who observe the desired innovation and make the mental connection that it might have great value in the environment of focus. The IMR Group described this mental connection as an "epiphany".

Perhaps because of the time required to expose the desired innovation to the environment – or because the Connector realizes the epiphany might have many applications beyond their own perspective – this epiphany state is one of the primary catalysts for engagement of innovation management. The agility of the innovation management area allows rapid exposure and the ability to bring in people with different points of view from various parts of the organization. If time or organizational structure are not factors then the activity might be managed by traditional research and development.

The IMR Group wonders if DSR might help in this area via:

- Epiphanies are sometimes hard to understand as they are not documented in formal ways. Can DSR help us learn more about this area?
- Epiphanies by subject matter experts or influential business leaders are accepted and provide over 50% of the work managed by innovation teams of the IMR Group. But the group believes there are lots of epiphanies that are not heard or understood. Can DSR help us learn more about this area?

As a deliverable of the Challenge stage, the IMR Group recommends the generation of a single artifact, a Challenge Scoping Document. This document would include:

- the frame for the innovation activity including in and out of scope statements
- timing
- business / functional area for investigation and application
- resources available for effort including people involved in creative thinking about it
- success factors
- proposed methodologies to be applied to the challenge

3.2 Refinement Stage Observations

The IMR Group believes the DRIVES Refinement Stage is another key area where DSR can better support industrial innovation. There is a significant concern that if innovation artifacts not framed properly the likelihood that ideas and solutions might be missed is high.The IMR Group believes the following methods can be leveraged in refinement:

- Idea expansion (group tests a submitted ideas and augments as appropriate)
- Idea Evaluation: sorting by success criterion
- Idea Theme identification
- Rapid Prototyping
- Proposal Documentation

Output from the refinement stage often triggers another round of ideation to expand creative thinking, which in turn is followed by another cycle of refinement. The IMR Group knows that there are many areas where DSR might add value to Innovation in this refinement stage as it takes concepts generated by the art of creative thinking in the ideation stage and judgments are applied to identify the wheat from the chaff. But participants also know that great new ideas and concepts can be lost without clear and rigorous criteria for the build-evaluate cycle as dictated by DSR.

3.3 Future Directions

The IMR Group will remain engaged with this research on applying DSR concepts to innovation processes. The group is actively studying all stages of the DRIVES model for important value-added ideas for corporate innovation processes. This research is being undertaken in conjunction with the Innovation Value Institute (www.ivi.ie) [2-3]. Applying the principles of engaged scholarship [9, 14], innovation is being investigated using a design process with defined review stages and development activities based on the DSR guidelines advocated by Hevner et al. [7]. Using a case study approach supported by semi-structured interviews, researchers will investigate the practice of innovation in some of its consortium members. A focus of the research is the design decisions and rationale underpinning innovation processes so that the relationship between DSR and Innovation might be better understood.

References

1. Anderson, J., Donnellan, B., Hevner, A.: Exploring the Relationship between Design Science Research and Innovation: A Case Study of Innovation at Chevron. In: Helfert, M., Donnellan, B. (eds.) EDSS 2011. CCIS, vol. 286, pp. 116–131. Springer, Heidelberg (2012)
2. Curley, M.: Managing Information Technology for Business Value. Intel Press (2004)
3. Curley, M.: Introducing an IT Capability Maturity Framework. In: Cardos, J., Cordeiro, J., Filipe, J. (eds.) ICEIS 2007. LNBIP, vol. 12, pp. 63–78. Springer, Heidelberg (2007)
4. Govindarajan, V., Trimble, C.: The Other Side of Innovation: Solving the Execution Challenge. Harvard Business Review Press, Cambridge (2010)
5. Gregor, S., Hevner, A.: Positioning and Presenting Design Science Research for Maximum Impact. Management Information Systems Quarterly 37(2), 337–355 (2013)
6. Gregor, S., Jones, D.: The Anatomy of a Design Theory. Journal of the Association of Information Systems 8(5), Article 2, 312–335 (2007)
7. Hevner, A., March, S., Park, J., Ram, S.: Design Science in Information Systems Research. Management Information Systems Quarterly 28(1), 75–105 (2004)
8. Kelley, T., Littman, J.: The Art of Innovation: Lessons in Creativity from IDEO, America's Leading Design Firm. Doubleday, New York (2001)
9. Mathiassen, L., Nielsen, P.: Engaged Scholarship in IS Research. Scandinavian Journal of Information Systems 20(2) (2008)
10. Newell, A., Simon, H.: Computer Science as an Empirical Inquiry: Symbols and Search. Communications of the ACM 19(3), 113–126 (1976)
11. Sein, M., Henfredsson, O., Purao, S., Rossi, M., Lindgren, R.: Action Design Research. Management Information Systems Quarterly 35(1), 37–56 (2011)
12. Simon, H.: The Sciences of the Artificial, 3rd edn. MIT Press, Cambridge (1996)
13. Venkatesh, V., Davis, F.: A Theoretical Extension of the Technology Acceptance Model: Four Longitudinal Field Studies. Management Science 46, 186–204 (2000)
14. Van de Ven, A.: Engaged Scholarship: A Guide for Organizational and Social Research. Oxford University Press, Oxford (2007)

Engaging Practitioners within Design Science Research: A Natural Language Processing Case Study

Seán O'Riain, Edward Curry, and Paul Buitelaar

Digital Enterprise Research Institute (DERI),
IDA Business Park, Lower Dangan, Galway, Ireland
{sean.oriain,ed.curry,paul.buitelaar}@deri.org

Abstract. Using domain knowledge to instruct domain specific Natural Language Processing (NLP) applications requires that knowledge intensive design challenges associated with developing extraction rules and conceptual models from that knowledge be addressed. Applying the nested problem-driven approach of Design Science Research (DSR) assists knowledge problem reduction to practical problems, delivering artifacts of utility. Where artifact design has to facilitate practitioner and research stakeholder expectations, dual leveraging of design process stages and conceived artifacts is required. This paper presents how an existing Information Systems (IS) framework, previously applied to enterprise architecture research, can be adapted to enhance stakeholder engagement within a collaborative informatics research project. The business motivation behind domain specific NLP is explained and design challenges encountered in framework application to use case development, discussed. Further contributions that outline artifact evolution using problem decomposition are made through integrating expert domain knowledge and design knowledge translation as part of the adapted research process.

Keywords: Natural Language Processing, NLP, Information Extraction, Design Science Research, Financial Analytics, Ontology Modeling, Knowledge Transformation.

1 Introduction

For academics engaged in information systems (IS) industrial collaboration, balancing industrial expectation with academic research pursuits is a constant challenge. Disconnects between research partners and practitioners ensure that activities with either complimentary or common goals are often overlooked and opportunity to leverage output in respective fields is seldom realized to its full potential. Ensuring that research activity remain practicable and relevant while at the same time delivering a quantifiable research contribution to the knowledge base, demands artifacts that satisfies both research partner and industrial practitioner expectations. Overlap do exist; both Design Science and an application domain environment produce results of knowledge and artifacts as models, constructs, methods and instantiations [1-3]. Introducing clarity between researchers on the one hand and practitioners on the other requires

M. Helfert and B. Donnellan (Eds.): EDSS 2012, CCIS 388, pp. 155–169, 2013.
© Springer International Publishing Switzerland 2013

that adequate collaborative engagement takes place supported by rigorous procedures that satisfy expected solution artifact delivery.

To investigate this dynamic we apply Design Science Research to the IS sub-domain of Natural Language Processing (NLP), specifically addressing the framework adopted, its differing deliverable types and how they can be assessed and measured by researchers and practitioners as stakeholders. Using a collaborative industrial - research informatics project[1] (described in Section 1.1) we outline how the framework facilitates practitioner business need through the application development of a qualitative decision support system on the one hand and researcher knowledge base contribution on the other, using complimentary artifacts design (cf. Section 4). Adhering to design-orientated information systems research process principles [4], and design-science research guidelines [1], our methodology in keeping with Meyer [3], centers on the intended application environment, artifact development and its changing nature throughout the research process. Key to our contribution and in similar vain to Wieringa [5], is the application of DSR's nested problems decomposition approach to research project structuring, allowing research methodology stages enrichment with researcher artifact output and its alignment with existing practitioner artifact output. Our research aims to reinforce existing IS design theory by providing guidance to collaborative research projects participants in terms of achieving engagement that delivers on these differing end goal expectations.

This paper is structured as follows: Section 1.1 first introduces the business motivation driver behind the research use case and the design goals required. In Section 2, NLP, positioned under the broader area of Information Extraction considers implications for Design Science stemming from the design goals. Adaption of Design Science frameworks and methodology to reconcile practitioner and researcher artifact and deliverable expectations are introduced in Section 3. Section 4 discussed research process application to our informatics use case and lessons learned are presented in Section 5. Section 6 concludes the paper.

1.1 Business Motivation and Value Proposition

Competitive analysis is used as an investigative tool by business analysts to deliver insight into critical business processes. Those processes include: a firms or competitor's operations and strategy; understanding market movement; identifying competitors; determining strengths and weaknesses; and prediction of the next strategic and tactical moves [6]. Competitive analysis monitors competition or environmental factors, captures essential measures of activity, and organizes those measures to help decision makers detect and respond to changes [7]. In particular, the free text management statements that comment on corporate performance and intangibles such as people, brands and patents are actively searched for key information and interpretation of company position. Manually locating and correlating key information from within the financial statements is recognized as presenting particular difficulty due to their textual nature, lack of structure and lack of common format [8]. The filings size

[1] Concentrating on the areas of competitive intelligence that targets fact extraction from business reports.

and sheer volume, ensures that up to 75% of analyst resource availability is expended in information gathering to support analysis [9]. Previous investigations have noted that analysts conducting such manual information acquisition dedicated 12.5% of available time to searching the filings introduction sections and establishing where in the filing to look for relevant information and the remaining 87.5% analyzing the identified sections [10].

The use case company, due to changing business practices, tasked its Business Process Outsourcing (BPO) team with the identification of software vendors as potential sources of new business opportunity for the outsourcing of their software and supporting production services. Manual competitive analysis was their main analytical tool. An artifact that could reduce the level of manual effort while assisting in identifying key pieces of information to better support competitive intelligence insight was required. Design goals contributing to the emergence of such an application artifact would minimally have to support individual knowledge transformation processes of: i) linguistic modeling of filing narrative section based on analyst heuristics and insight; ii) automated linguistic analysis of filing using the conceptual linguistic model; and iii) an artifact that provides an environment to support analyst perform the competitive intelligence task.

2 Natural Language Processing Implications for IS Research

Information Extraction (IE) as a fundamental process involves taking unstructured text input and outputting formatted unambiguous data [11]. IE systems can be categorized as adhering to knowledge engineering (KE) or machine learning (ML) approaches. KE depends on domain expert knowledge to hand craft extraction rules that are used to automatically identify and extract information as part of a natural language processing activity. ML on the other hand utilizes algorithms to train on annotated text and automatically generate extraction rules[2]. IE applications in specialized information domains such as financial, business, medical or biology are hugely reliant on this domain knowledge to define the conceptually complex information sought[3]. Central to any KE successful design is the process used to formally represent that knowledge and its decomposition into manageable sub-processes.

Any DSR originating methodology applied to this environment must therefore take account of and allow for knowledge intensive processes involving domain expert practitioners at all levels of the research methodology. Knowledge intensive processes have however challenging information requirements. They require knowledge and expertise in its application. Markus et al. [12] researched design problems providing IT support to a class of user requirements termed emergent knowledge processes (EKP). Product development and strategy-making are organizational EMP examples

[2] For discussion on general data extraction methods we refer the reader to [13] and for data mining techniques related to financial applications to [14].

[3] For example, in business the concept of 'market movement' is more difficult to define and identify in text than concepts such as person, location or lesser events.

that bring a level of practitioner uncertainty. EKPs' are characterized by: i) emergent processes of deliberations with no best structure or sequence; ii) unpredictable actor sets with regard to job role or prior knowledge and; iii) knowledge requirements for general and specific distributed expertise [12]. Problem solving within Design Science has been classified as mutual nesting of knowledge problems and practical problems [5]. Design questions can contain knowledge questions which can in turn be decomposed into known practical sub-problems solvable with existing methodologies. Knowledge questions are answerable from the knowledge base or with further research such as conceptual analysis, empirical research using experiments, case studies or modelling. Practical problems are solved by matching problems and solution as part of a regulative cycle [5].

Characteristics of NLP are only partly shared with EKPs. The customizable ability of knowledge engineering based NLP ensures that a best structure, typically minimally represented by a semi-formal model, emerges. Both the practitioner and required knowledge must be identified during design for a rule set to emerge. The last characteristic of dependency on both general and specific environmental knowledge is shared with EKP. For specialized domain applications knowledge can be derived from that generally available in the knowledge base in the first instance (e.g. in finance: standards, best practices and regulatory rules) and practitioner heuristic knowledge processes (e.g. operational know how, experience). DSR application to the area of customizable NLP is therefore suitable as its frameworks support IS artifact design and development through its nested problem solving capability, allowing the reduction of knowledge problems into manageable practical problems. Understanding the evolving artifact state throughout the design process and the accommodation of practitioner and researcher engagement as part of that process, is key to ensuring that resulting artifact deliverables reflect stakeholder need. Accommodating this engagement, as will be discussed, proved to be critical for research success. Similarly, principled uses of DSR has seen its application to developing modeling techniques for service design [15] and both direct and indirect effects of environmental sustainability on artifact design [16].

3 Design Science Application to Natural Language Processing

The methodology used adheres to the design-orientated information systems research process guidelines and principles from [4], and design-science research guidelines from [1]. The overall methodology applied in our use case follows the four basic process phases of analysis, design, evaluation and diffusion [4]. Principles outlined in Table 1, consider each DSR principle from an NLP knowledge intensive view point. The considerations are reflected in the research framework (cf. Section 3.1), and abstracted in the research methodology (cf. Section 3.2). Detail discussion is left to the case study in Section 4.

Table 1. Aligning DSR guidelines to Information Extraction

Guideline	**Description**	**Consideration for IE**
Design as an artifact	DSR must produce a viable artifact in the form of a construct, model method or instantiation	We designed a number of artifacts that contribute towards a main construct that supports a business analyst: an ontology to specify the information requirement; a linguistic analytics pipeline that provides that information and; a qualitative DSS, that combines these artifacts, supporting an analyst find and retrieve information
Problem Relevance	Objective of DSR is to develop technology based solutions to important and relevant business problems	Established by business stakeholders. In general consideration of any enhancement in the provision of contextualized information has business utility and value
Design Evaluation	Utility, quality and efficacy of a design artifact must be rigorously demonstrated with well executed evaluation methods	Artifact was implemented and evaluated as part of an industrial use case and demonstrator, using domain experts
Research Contribution	Effective DSR must provide clear and verifiable contributions in the areas of the design artifact, design foundations and/or design methodologies	The research contribution is centered on the design artifacts that concentrate on the ability to specify information sought and its provision to the relevant audience
Research Rigor	DSR relies on the application of rigorous methods in both the construction and evaluation of design artifacts	For both design and evaluation methods we utilised methods from computer science, information retrieval and information science to deliver research rigor
Design as a search process	Search for an effective artifact requires utilising available means to reach desired ends while satisfying laws in the problem environment	Each stage of the design process was performed iteratively and in collaboration with the business stakeholders. Stakeholder engagement ensured that environmental needs and rules are satisfied, and that a rich knowledge base was also available
Communication of research	DSR must be presented effectively both to technology-orientated as well as management-orientated audiences	Our research, multidisciplinary in nature, required both business and technical knowledge. Dissemination activities have targeted the management-orientated Business Intelligence and technology-orientated semantic applications audiences

3.1 Research Framework

As illustrated in Figure 1, the IS framework employed is based on Henvers [2] original three cycle view of DSR and recent model modification to cater for its application to business value assessment for Enterprise Architectures [3]. The *Environment* consists of the company's application domain, organizational strategy, processes and technology and applicable stakeholders. The environment informs on relevant business problems, need and application context, allowing artifact requirement definition. Acceptance criteria is also included as part of the relevance cycle to ensure on-going artifact alignment with business need and research design goals. Artifact design was explored using the companies *Knowledge Base* for exploitable frameworks or technology offerings. Where recommendations were not forth coming, the academic knowledge base was also interrogated for foundational technologies such as linguistic analysis [10, 14, 17] and complementary methodologies from information systems to assist with knowledge representation (i.e. ontology development [18, 19]) then can be adopted as necessary. *IS Research* leverages design-orientated information systems research process guidelines and principles [4] specifically to assist with artifact identification and evolution. The research guidelines are expanded with a research methodology (cf. Section 3.2) adapted to enhance practitioner and researcher engagement and meet their different artifact expectations. Artifact design rigor was enhanced using the principles of [3, 4], namely: abstraction, ensuring that artifacts solved a class of problems; originality, catering for artifact contribution to both knowledge bases; validation, artifacts must be justified and; benefit, artifacts must deliver business value to stakeholders.

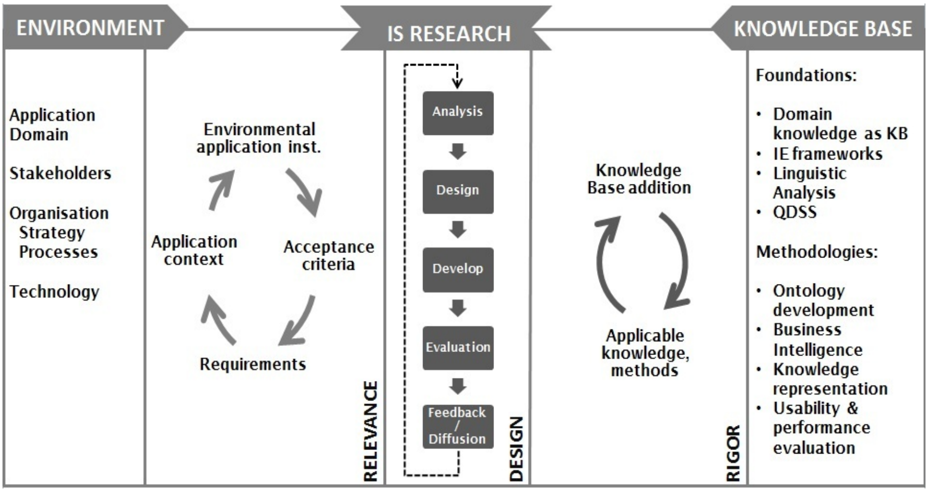


Fig. 1. DSR Framework adapted from [2, 3]

3.2 Research Methodology

The IS Research process used focused on the four process phases of evaluation, design, evaluation and diffusion [4]. Each phase is broken down into sub-stages (as indicated by the process boxes) that prompt design questions and decomposition of knowledge problems into practical problems [5]. Each process box has associated artefact output represented by document boxes. Practitioner interest artefacts are listed under processes boxes as the left most document box and researcher as the right. Discussion on artifact evolution and the engagement necessary between stakeholders to achieve these documents as part of the design process is presented in Section 4.

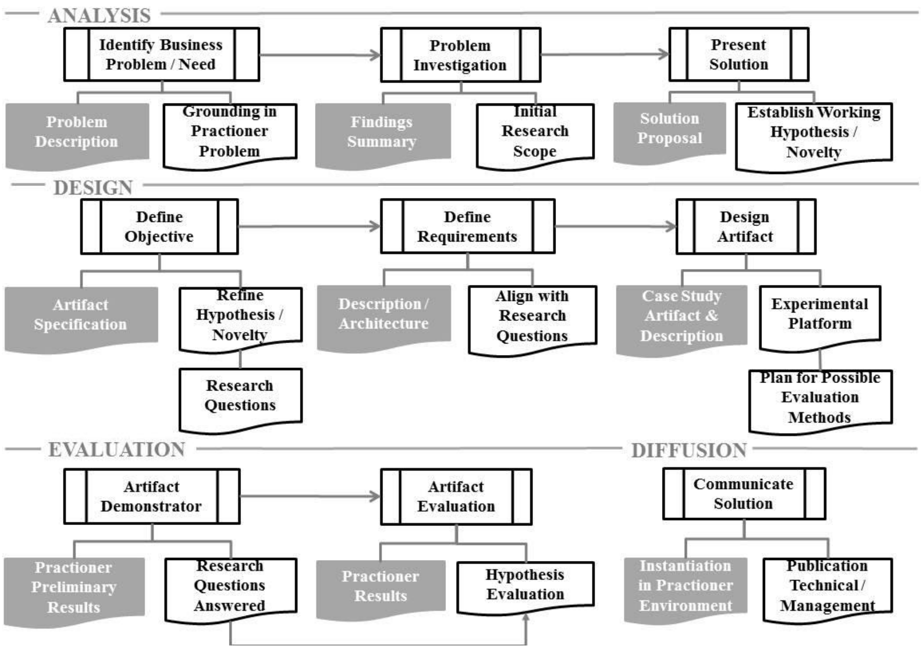


Fig. 2. Research Methodology including deliverables adapted from [3]

4 Case Study: DSR Application to Business Informatics

Our use case involved the validation and evaluation of our approach (defined in Section 3.2) as part of a collaborative academic-industrial informatics research project. Practitioners were driven by the development of a qualitative decision support system to support business analysts perform a competitive analysis, while researchers had as goal, novel knowledge base artifact contribution (e.g. domain specific term lists, concept maps, ontologies), driven by a series of research questions, evaluated against a working hypothesis. The application of each research process phase to enhance stakeholder engagement and progress the use case is next discussed.

Analysis. The analysis phase established the business relevance, performed initial problem investigation and proposed a possible solution. The analysis was divided into three steps (cf. Figure 2). The first step concentrated on establishing the business need. Using the business motivation (Section 1.1) as background, a series of practitioner consultative interview sessions were undertaken with their business analyst team. The interviews investigated current knowledge base usage by practitioners reinforced with demonstrations to clearly define the environmental business problem. For practitioners this provided an initial frame of reference for the type of design artifact required and for researchers a context and level of transparency for the type of design innovation expected. Early engagement with stakeholders ensured that each had an understanding of the others interest areas and expectations from the project outset. Defining a class of environmental business problems was used to progress problem investigation. Generalized recommendations regarding the development of new or customizations of existing IE/NLP systems [13] were first considered. Table 2 lists for each problem class design question summaries that outline influences on potential artifact design. An accompanying priority rating indicates the importance of addressing the problem class to the practitioner.

Table 2. Problem classes general to IE

Problem Class	Design Question Summary	Priority
Adequate specification of IE requirement	Is IE/NLP a suitable approach for the information task? Does the implementation cost outweigh expected results and does the enterprise have in-house technical competency? Would system predictability be better than random or might information retrieval results prove comparable or better? What is the resource overhead associated with rule maintenance, lexical resources and preparation of training data?	High
Availability of Knowledge resources	Is there availability of sufficient quantity and quality training data? If not, what is the cost of training data creation, accessibility to domain experts and availability of knowledge engineers for activities such as rule construction? Are there linguistic resources (e.g. dictionaries, taxonomies, ontologies or business specifications) that can be exploited?	High
Dealing with multiple text types:	What are the relevant source formats and text types that have to be gathered, processed and indexed? Will new domain information, language identification features, text genres and multilingual capability be required?	High for English
Adaptivity / reusability:	Will any created dictionaries, term lists or training data be adaptable to different business tasks?	Medium
Scalability	What type of processing response is required: Real time, off-line processing, or parallel?	Low

The generalized problem classes were found to be at too high a level to assist practitioners with emergent requirements or researchers with research scope and required further decomposed into specialized problem classes. Using the problem description and information gathered from the academic knowledge base, the financial IE problem class set (Table 3) complete with major design activities areas were defined. Influenced by the problem description, the sub-domain problem classes allow findings summary generation for the practitioner and based on knowledge base investigation, a research scope based on an initial set of working assumptions. Defining the problem class set ensured close engagement and problem understanding between stakeholders.

Step 3 saw the solution proposal presented to stakeholders for review. Conditional approval from multiple practioner roles was required, namely: management for access to domain expertise and environmental knowledge base, business for access to relevant sources, and technologists for assessment of solution offerings and technology fit within the application environment to business need. For researchers, identifying gaps in the knowledge base when considering solution design provided insight as to where innovative design could be applied, novelty contributed and a working hypothesis established. Using problem investigation and solution proposal to reconcile stakeholder understanding and achieve broad consensus on solution and research direction was instrumental in both establishing and consolidating stakeholder engagement.

Table 3. Problem classes specific to financial IE

Problem Class	**Design Question**	**Solution / IT Artifact**
Extraction task supported	What is the financial/business sub-domain activity that the information extracted will directly support?	Competitive analysis with the Analyst Work Bench
Text type	What filing type to support text extraction from?	Construct to support extraction from XBRL / XML filings
Solution approach	Use the knowledge engineering or machine learning approach for extraction?	Construct Linguistic analytics pipeline using KE approach
Language model	Use a conceptual model to define domain linguistic and drive actual extraction?	Competitive Analysis Ontology
Lexical resource engineering	Development or use of existing domain lexical resources to support the solution approach?	Domain knowledge extraction as: i) process and ii) model

Design. The design phase defines objectives, requirements and artifact design steps motivated by the business need. Clear and attainable objectives that aligned with artifact delivery from the problem statements (Table 3) and that also represents our research problem analysis are presented in Table 4. Although the artifact objectives are practitioner biased, the artifacts themselves evolved with researcher engagement through assessing their suitability to answer research questions and contribute to hypothesis evaluation at the evaluation stage. Based on the artifact objectives and agreed solution proposal (from the analysis phase), a detailed functional specification was produced along with an opportunity for researchers to re-visit their working hypothesis and define research questions that enable hypothesis validation. Stakeholder engagement during requirements definition allowed practitioners to introduce new or modify existing artifact functional specification and researchers an opportunity to validate whether developed artifacts would be apt to answer research questions.

Table 4. Design Solution Artifact Objectives

Artifact	**Objectives**
Competitive analysis with the Analyst Work Bench	Application that assists an analyst find relevant information as part of competitive analysis task performance
Construct to support extraction from XBRL[4] / XML filings	Improve ability to deal with regulatory reporting formatting standards
Construct Linguistic analytics pipeline using KE approach	Improve identification and extraction of relevant information through semantic mark up of business filings
Domain knowledge extraction as: i) process and ii) model	Capture tacit knowledge relating to competitive analysis task performance, information provision and information associations
Competitive Analysis Ontology	Formally represent knowledge requirement relating to competitive analysis task performance

[4] eXtensible Business Reporting Language, a global standard for expressing the semantic meaning of information in business reports and its exchange, refer to `http:/www.xbrl.org/`.

Design knowledge frameworks that capture design knowledge across a multi-stage process that progresses individual design knowledge (implicit), to explicit design knowledge and finally computational design knowledge, have been proposed for ubiquitous information systems development projects [20]. The design process culminates with design knowledge representation as a knowledge object. The development process is perceived as a knowledge transformation system that does not distinguish between product and information. Generally suitable for our purposes we further define steps to take account of our knowledge intensive requirements for specialised application of NLP to financial IE. Knowledge problems identified from artifact objectives and requirements, relating to knowledge capture and conceptualization, triggered decomposition into practical sub-problems and existing methodologies were then applied to resolve them [5]. Table 5 shows the problem decomposition necessary for knowledge capture through to conceptualization and ontology generation based on the DOGMA[5] ontology development methodology [19]. Knowledge problems are first aligned with stages of DOGMA's domain conceptualization. Methods employed to decompose the problem into a practical problem are given and the resulting artifacts listed. For example knowledge elicitation and breakdown used contextual enquiry to perform discourse analysis and generate discourse term lists, concept maps[6] and their organization into statements of propositions. A similar activity that proposes the translation of process narratives (description of usage situations in natural language) into diagrammatic conceptual models termed pre-artifacts is found in Maass and Janzens' knowledge framework [20].

Table 5. Knowledge problems aligned with Ontology Modeling Methodology based on [19]

Knowledge Problem	**Method**	**Generated Artifact**
Knowledge elicitation Knowledge breakdown	Contextual enquiry Discourse analysis	Discourse term list Concept maps Concept proposition templates Semantic Paths Verbalized elementary sentences
Verbalized elementary sentences Knowledge negotiation Knowledge discovery	Concept proposition templates Semantic Paths Lexon Engineering	Extraction rules Ontology concept primitives Competitive Analysis Ontology

Using problem decomposition as the vehicle for design knowledge transformation introduced progressive artifact state change that had a direct bearing on stakeholder engagement and expectation management. Practitioner interest concentrated on progression towards final artifact design. Researchers on the other hand sought to assess:

i) Alignment of individual artifacts to inform on individual research questions
ii) Whether there were any usage or setup issues that may impact experimental validation performance and
iii) Fitness-for-purpose of the final artifact as an experimental platform to validate hypothesis against

5 Developing Ontology Grounded Methods and Applications

6 Semi-formal design knowledge based on a graph model with binary relationships between node (concept) types

Problem decomposition demanded selection of appropriate methodologies to address emergent practical problems. An observation regarding formal conceptual models was the lack of reliance on their use as a design tool for IS designers [20] but use instead as computational design knowledge. Our engagement model found this to be the case with the additional observation that semi-formal models (e.g. concept mappings) attracted greater interaction and usage from practitioners and formal models (e.g. ontology representation) attracted interest from researchers. Having respective stakeholders aware of artefact state but only taking ownership for those that matched their end goals, ensured that artefact design and development met expectations.

Evaluation. Having established design artifacts of interest during the design phase, stakeholders next progressed to perform instantiation and preliminary assessment of those artifacts relating to analysis goals, problem categories and design objectives. Specifically for researchers artifacts generated from addressing practical knowledge problems (Table 5) allowed research question evaluation. With feedback incorporated, the research process moved to the rigor phase and performing comprehensive evaluation of the main artifact based on design objectives and goals. Earlier stakeholder design phase discussions identified a number of areas where experimental design, setup and execution required further close engagement, owing to:

i) Artifact contribution validation through competitive analysis task information provision and effect on the qualitative aspects of task performance
ii) Knowledge complexity associated with verifying objectives and goals, demanded that evaluation take place within an organizational context and be performed using domain experts
iii) The alignments of design phase case study document descriptions with objectives, identifying that performance and usability evaluations were required

Criteria adopted for verifying artifact performance and usability are outlined in Table 6. The academic knowledge base provided the performance methods from information retrieval and usability measures from information science. Performance delivers a quantitative set of results and usability a qualitative set. Worthy of mention is that evaluation criteria for knowledge depends more on its truth value with respect to the subject domain of the knowledge rather than stakeholder goals [5], reinforcing the need for domain expert assessors. Post evaluation there is opportunity to re-visit the artifact analysis with corrections or modification to the original solution approach and design.

Table 6. Evaluation Criteria

Criteria	Performance	Usability
Artifact usable as basis for experiment	AWB QDSS, as a provider of relevant information	AWB, as an interactive QDSS
Criteria representing system objectives	Relevance of information provided	Usefulness/usability of information provided and DSS environment
Measuring instrument	Relevance judgment expresses as a binary weighting	Success determination using Likert scale
Measures	Precision, recall	Weighted average
Methodology for measurement, evaluating performance	Based on the competitive analysis task	Questionnaire survey of participant usage of artefact

Diffusion. Managing artifact state change increased the frequency of artifact availability and opportunity for dissemination exploitation across the broader research process rather than post phase completion. For researchers this represented business information system [23] and domain technology-orientated [24] publication audiences [1]. Practitioners on the other hand looked to use case demonstrator instantiation within their environment.

5 Lessons Learned

Based on the application of our research methodology to a collaborative research informatics project we have identified the following four lessons that can be applied by practitioners and researchers in other projects. We believe these lessons are equally applicable within general knowledge engineering dependent business analytics activities and collaborative research projects.

i) Align Business and Research Objectives
A key requirement is to align the business problem with researcher design objectives. Alignment success was attributed to researcher grounding in the practioner problem, early establishment of environmental problem classes and their use to direct knowledge base searches. Knowledge base searches were instrumental in identifying research novelty, solution design and project scope. Adhering to this approach we were able to identify solution novelty relative to stakeholder design objectives and goals, establish research questions and hypothesis and align project direction with stakeholder research interests from the outset.

ii) Manage Stakeholder Design Expectation
It is important that competing stakeholder deliverable expectations be actively managed. While systemic use of knowledge problem decomposition is a useful tool to progress research design artifacts it is understanding of the changing state of emergent artifacts to expedite shareholder exploitation that is the more significant challenge. Combining both is mandatory for stakeholder design expectation management. Process problem decomposition incrementally drives delivery of solution component artifacts but state change allows researchers recognize those suitable for research question answering and practioners, the opportunity for milestones assessment toward solution delivery. Within the project, problem class definition drove design requirements which in turn aided knowledge problem identified and addressing knowledge problems accommodated the introduction of researcher design objectives. Subsequent stakeholder agreement and management of the design artifact delivery ensured expectation was met.

iii) Early Consideration of Rigor
Contemplation of rigor should not be restricted to an obvious evaluation phase only. Any stage of the research process that advocates some solution or design activity should routinely be considered in terms of influence on, or suitability for, stakeholder success determination. Planned dual use of component artifacts delivers the environmental conditions for research question appraisal. Overall success determination is

more complex, requiring the assembly of rigor criteria that is cognisant of environmental business objectives and research goals. Criteria shapes respective stakeholder evaluation and use of the practioner DSS artifact as the experimental platform caters for hypothesis evaluation. Adhering to this scheme ensured that the research process was successful in delivering the expected outcomes of both stakeholders.

iv) Stakeholder Engagement
Resolute stakeholder engagement from project inception is a prerequisite for project success. Close collaboration between practioners and researchers along the entire research process can be used to reconcile deliverable and therefore stakeholder expectation, provided that the business problem is clearly established and understood and business objectives are aligned with research goals. In particular stakeholder immersion in the design phase stages is an excellent opportunity for deliverable reconciliation. Active engagement was singularly the largest contributory factor to overall project planning and success through its formation of project technical direction and deliverable generation, based on solution design and knowledge base gaps.

6 Conclusions

This article describes methodology enhancements made to a practical DSR application [3] framework to actively support the level of practitioner and research engagement necessary to accommodate differing artifact expectations that arise in collaborative research projects. Steps used in the overall design research methodology are discussed using a collaborative industrial-academic research project. The project focuses on knowledge translation and modeling intensive design activities that accompany natural language processing introduction and deployment. While further verification of the framework design and evaluation stages is necessary, we believe that the framework as construed, accompanying discussion on application and lessons learned can be applied to other projects seeking to enhance delivery of meaningful research output to industry and attracting academics to participate in industrial led projects.

Acknowledgements. The work presented in this paper has been funded in part by Science Foundation Ireland under Grant No. SFI/08/CE/I1380 (Lion-2), and the EU FP7 MONNET project under Grant Agreement No. 248458.

References

1. Hevner, A.R., Salvatore, T., March, S.T., Jinsoo Park, J., Sudha Ram, S.: Design science in information systems research. MIS Q. 28(1), 75–105 (2004)
2. Hevner, A.R.: A Three Cycle View of Design Science Research. Scandinavian Journal of Information Systems 19(2), 87–94 (2007)

3. Meyer, M., Helfert, M., Donnellan, B., Kenneally, J.: Applying design science research for enterprise architecture business value assessments. In: Peffers, K., Rothenberger, M., Kuechler, B. (eds.) DESRIST 2012. LNCS, vol. 7286, pp. 108–121. Springer, Heidelberg (2012)
4. Osterle, H., Becker, J., Frank, U., Hess, T., Karagiannis, D., Krcmar, H., Loos, P., Mertens, P., Obrweis, A., Sinz, E.J.: Memorandum on design-oriented information systems research. Eur. J. Inf. Syst. 20(1), 7–10 (2011)
5. Wieringa, R.: Design science as nested problem solving. In: Proceedings of the 4th International Conference on Design Science Research in Information Systems and Technology, Philadelphia, Pennsylvania. ACM (2009)
6. Sheng, Y.P., Mykytyn, P.P., Litecky, C.R.: Competitor Analysis and Its Defences in the EMarketplace. Communications of the ACM 48(8), 107–112 (2005)
7. Sauter, V.L., Free, D.: Competitive intelligence systems: qualitative DSS for strategic decision making. In: SIGMIS Database. ACM Press, New York (2005)
8. Grant, G.H., Conlon, S.J.: EDGAR Extraction system: An automated Approach to Analyze Employee Stock Option Disclosures. Journal of Information Systems 20(2), 119–142 (2006)
9. Zahra, S.A., Chaples, S.S.: Blind Spots in Competitive Analysis. The Academy of Management Executive (1993-2005) 7(2), 7–28 (1993)
10. O'Riain, S., Spyns, P.: Enhancing the Business Analysis Function with Semantics. In: Meersman, R., Tari, Z. (eds.) OTM 2006. LNCS, vol. 4275, pp. 818–835. Springer, Heidelberg (2006)
11. Cunningham, H.: Information Extraction, Automatic. In: Encyclopedia of Language and Linguistics, pp. 665-677 (2006)
12. Markus, M.L., Majchrzak, A., Gasser, L.: A design theory for systems that support emergent knowledge processes. MIS Q. 26(3), 179–212 (2002)
13. Appelt, D.E., Israel, D.J.: Introduction to Information Extraction Technology. In: International Joint Conference on Artificial Intelligence (1999)
14. Zhang, D., Zhou, L.: Discovering golden nuggets: data mining in financial application. IEEE Transactions on Systems, Man, and Cybernetics, Part C: Applications and Reviews 34(4), 513–522 (2004)
15. Lessard, L., Yu, E.: Using Design Science Research to Develop a Modeling Technique for Service Design. In: Peffers, K., Rothenberger, M., Kuechler, B. (eds.) DESRIST 2012. LNCS, vol. 7286, pp. 66–77. Springer, Heidelberg (2012)
16. vom Brocke, J., Seidel, S.: Environmental sustainability in design science research: Direct and indirect effects of design artifacts. In: Peffers, K., Rothenberger, M., Kuechler, B. (eds.) DESRIST 2012. LNCS, vol. 7286, pp. 294–308. Springer, Heidelberg (2012)
17. Li-Yen, S., Ching-Wen, C., Shiue, W.: The development of an ontology-based expert system for corporate financial rating. Journal of Expert Systems with Applications 36(2), 2130–2142 (2009)
18. Jarrar, M., Meersman, R.: Formal Ontology Engineering in the DOGMA Approach. In: Meersman, R., Tari, Z. (eds.) CoopIS/DOA/ODBASE 2002. LNCS, vol. 2519, pp. 1238–1254. Springer, Heidelberg (2002)
19. Spyns, P., Tang, Y., Meersman, R.: A model theory inspired collaborative ontology engineering methodology. Journal of Applied Ontology 4(1) (2007)
20. Maass, W., Janzen, S.: Towards design engineering of ubiquitous information systems. In: Peffers, K., Rothenberger, M., Kuechler, B. (eds.) DESRIST 2012. LNCS, vol. 7286, pp. 206–219. Springer, Heidelberg (2012)

21. Baskerville, R.: What design science is not. European Journal of Information Systems 17(5), 441–443 (2008)
22. Livari, J., Venable, J.: Action research and design science research-seemingly similar but decisively dissimilar. In: 17th European Conference on Information Systems (2009)
23. O'Riain, S., Curry, E., Pinsker, R.: Competitive Analysis of Business Filings Using Ontologies and Linguistic Analysis. In: Business Intelligence Congress 3: Driving Innovation through Big Data Analytics, Orlando, Florida (2012)
24. O'Riain, S., Curry, E., Harth, A.: XBRL and Open Data for Global Financial Ecosystems: A Linked Data Approach. International Journal of Accounting Information Systems 13(2), 141–162 (2012)

Author Index