THE CASE FOR DESIGN SCIENCE UTILITY

- EVALUATION OF DESIGN SCIENCE ARTEFACTS WITHIN THE IT CAPABILITY MATURITY FRAMEWORK -

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Abstract

Despite the increasing popularity of design science research, evaluating design artefacts is still challenging. Several guidelines and suggestions have been proposed, however combining practical utility and academic rigor can be difficult, in particular when research is co-funded by industry. In this research-in-progress paper we describe a novel IT Management model, the IT Capability Maturity Framework and its design process. In order to incorporate the evaluation of design artifacts along the design process within an open innovation community, we propose to use common information quality criteria and evaluate the design artefacts using the quality model. Particular focus is given to address both practical usability as well as rigor of the evaluation criteria by using well established information quality criteria. The research emphasizes the importance of evaluation and utility in Design Science Research.

Keywords: Design Science, Utility, Evaluation, IT-CMF.

1 Introduction

Despite the popularity of Design Science Research (DSR) limited practical contributions have been so far provided on how to evaluate design artefacts. Although there are several papers suggesting aspects of design evaluation and particularly emphasizing the utility criteria (Hevner et al. 2004; Iivari, 2007; Peffers et al. 2007; Hevner & Chatterjee 2010), a consistent and general evaluation approach is still missing. The challenge of incorporating utility measures along the design research process has not been sufficiently addressed yet. Furthermore defining suitable utility measures in collaborative and open environment, in which practitioners and academic researchers contribute to the artefact development has not received adequate attention.

This paper proposes to use information quality models as evaluation criteria in the development of design artefacts in DSR. The paper addresses the paucity of published research by exploring and explaining how design artefacts can be achieved in practice in the development of the design artefacts in the IT-CMF. The IT-CMF artefact development and review process is implemented by the IT-CMF development community in the Innovation Value Institute (www.ivi.ie). This community is comprised of university-based academic researchers and industry-based practitioner-researchers drawn from over 50 companies located throughout the world.

The research reported in this paper has been developed in the context of the IT Capability Maturity Model (IT-CMF), a high-level process capability maturity framework for managing the IT function within an organization (Curley 2004; Curley 2006a; Curley 2006b; Curley 2006c). The framework identifies a number of critical IT processes, and describes an approach to improving maturity for each process. We find the design environment with the IT-CMF in particular challenging and interesting as the design and review processes are based on "open innovation" principles. "Open innovation" as presented by Chesbrough (2003) offers an innovation model where organizations leverage both external and internal resources to generate value. This concept challenges the view of closed innovation where innovation processes are restricted to experts within the organization. By leveraging the collective intelligence of experienced practitioners in the IVI community, the information quality of the design artefacts in the IT-CMF is established and enhanced.

Objective of this paper is to provide an information quality oriented evaluation framework for DSR within the context of the IVI community that is both practical useful as well as ensures rigor in evaluating design artefacts. The evaluation framework is based on information quality criteria, which can be applied along a review process. The remainder of the paper is structured as follows: Section 2 describes the context of IT management and maturity models. Section 3 and 4 reviews the background and related work of DSR and outlines the research methodology. The overall design of the IT-CMF design process and evaluation framework is described in Section 5. We conclude our paper in Section 6 by outlining some research directions.

2 Evaluating Information Management Maturity Models

This work is carried out in the area of information management maturity frameworks. Information management (IM) has a wide scope and includes areas such as information strategic planning, project management, information systems development, architecture development, resource management, innovation management performance and quality management. In recent years much work has been done on categorizing and describing these areas into processes. Aiming to evaluate maturity of the information management processes within organizations, recently several maturity frameworks have been developed (Becker et al. 2009).

One frequent referred example is the Capability Maturity Model (CMM) (Paulk et al. 1993), which built the foundation for many subsequently developed maturity models and frameworks. More recent approaches relate to IT governance and service management, such as Cobit, CMMI or ITIL that provide comprehensive IT management descriptions (Johannsen & Goeken 2007). The frameworks include criteria describing distinct maturity levels together with assessment approaches that will assist an organization to identify its specific maturity status. Together with the assessment approaches most maturity models provide guidelines for improving information management systems. Maturity in this context refers to evolutionary growth in the capability to manage information, processes as well as systems and technology. (Humphrey 1989). Classifying capabilities can be useful for maturity assessments and can help companies assessing their own performance in relation to other companies. Furthermore by suggesting how to develop these capabilities, the model can help transforming organizations towards higher maturity levels.

The models provide valuable contributions containing best practices and experiences. However, despite the large number of maturity models, most practical relevant approaches and frameworks are limited in providing a rigor and transparent evaluation approach that facilitates engagement of scholars as well as considers a practitioner oriented design environment. This limits the value as well as applications of the models and furthermore underpins the importance of our research presented in this paper.

3 Research Methodology

Our research process to develop the proposed evaluation framework can be seen as elements of Design Science-oriented research process (Braun et al. 2005; Hevner et al. 2004). In this paper we scoped the problem and based our findings on reviewing relevant literature. The literature was collected primary from journals and prominent book contributions related to design science. The literature review was complemented by a series of discussion-type focus group meetings with researchers in the Innovation Value Institute sharing experiences and challenges on evaluating research results. This approach attempted to generate discussion and interaction to confirm our evaluation framework. The use of a design science oriented research approach in this environment provided the study with a considerable degree of richness. From the outset certain important notions and impressions emerged from the discussions and the analysis and these were subsequently developed as key findings. In the following we present first findings from our literature review and conceptual evaluation framework and then in section 5 the application within the Innovation Value Institute.

4 Design and Evaluation

In Design Science, two basic activities can be differentiated for the construction of artefacts: build and evaluate; where building “is the process of constructing an artefact for a specific purpose” and evaluation “is the process of determining how well the artefact performs” (Schön 1983, p. 254). In the centre of the two activities are design artefacts as the output of a design process. In the following we review literature and describe important characteristics of the build activity and the output of a design process. This leads us to the description of the proposed conceptual evaluation framework.

4.1 Design Process

The construction of an artefact is a heuristic search process in which extensive use of theoretical contributions and research methodologies should be made (Schön 1983). In Simon’s seminal contribution he demonstrated that natural science and the science of the artificial are different as the former is about analysis where the latter is about synthesis (Simon 1969). Based on this distinction Hevner et al. describe two distinct paradigms: behavioral science research and design science research

(Hevner et al. 2004). The former is understood as a "problem understanding paradigm", the latter as a "problem solving paradigm". Related to these considerations on designing artefacts, Van de Ven (2007) describes engaged scholarship as a participative form of research for obtaining the views of key stakeholders to understand a complex problem. By exploiting differences between these viewpoints, he argues that engaged scholarship produces knowledge that is more penetrating and insightful than when researchers work alone. Engaged scholarship has a number of facets; a ***form of inquiry*** where researchers involve others and leverage their different perspectives to learn about a problem domain; a ***relationship*** involving negotiation, mutual respect, and collaboration to produce a learning community and an ***identity*** of how scholars view their relationships with their communities and their subject matter. Mathiessan & Nielsen (2007) see engaged scholarship as a grand opportunity to address key challenges within the IS discipline in a novel and constructive way. They applied the principles of engaged scholarship to analyse Scandinavian IS research through the lens of Scandinavian Journal of Information Systems (SJIS). After reviewing all the research papers published in SJIS over the past 20 years; they advocated a role for engaged scholarship in shaping the future of Scandinavian IS research and IS research and practice in general.

Brattleteig (2007) draws attention to the emerging emphasis in Design Science as a systematic approach to design, making the design activity itself a scientific activity and contrasts it with 'scientific design' in industrial design that is based on scientific knowledge. His central argument is that if design includes the generation of ideas and the creation of alternative forms, it must be a non-linear and unpredictable processes – an anti-positivist position that maintains that knowledge is never neutral or complete and that the scientist is part of the scientific study. Furthermore, while there is no widely accepted definition of DSR, Livari & Venable (2009) define DSR as a research activity that invents or builds new, innovative artefacts for solving problems or achieving improvements, i.e. DSR creates new means for achieving some general (unsituated) goal, as its major research contributions. Such new and innovative artefacts create new reality, rather than explaining existing reality or helping to make sense of it (Hevner et al. 2004).

In summary, it has been argued that while Design Science, or design theory, was discussed over 50 years ago by Simon (1969), and further developed in the mid-nineties (March & Smith 1995) and the new millennium (Markus et al. 2002), it was the Hevner et al's (2004) publication that propelled Design Science out of its niche into the mainstream of the IS research community (Indulska et al. 2008). The central thrust of Hevner's approach was that Design Science attempts to create and evaluate IT artefacts intended to solve identified relevant organizational problems and he went on to propose a set of problem solving guidelines process where the understanding of a design problem and its solution are acquired in the building and application of an artefact. Following the contribution of design science, in Section 5.1 we describe a practical oriented research process to develop an IT maturity model as application of a design science methodology.

4.2 Design Output

In the centre of Design Science are innovative artefacts (Gericke et al. 2009), that according to Hevner et al. seeks to extend the boundaries of human and organizational capabilities (Hevner et al. 2004). March & Smith (1995) identify four design artefacts produced by design-science research in IS (March & Smith 1995). The artefacts are constructs, models, methods, and instantiations. The role of constructs is to provide the language in which problems and solutions are defined and communicated (Schön 1983). Models use constructs to represent a real world situation—the design problem and its solution space (Schön 1983). Models aid problem and solution understanding and frequently represent the connection between problem and solution components enabling exploration of the effects of design decisions and changes in the real world. Methods define processes. They provide guidance on how to solve problems, that is, how to search the solution space.

The result of design science research in IT is, by definition, a purposeful artefact created to address an important organizational problem. Artefacts are innovations that provide a degree of novelty into an application context. Hevner et al. (2004) define the artefact as the constructs, models, methods, and instantiations applied in the development and use of information systems. Some aspect of the artefact must be an original contribution to the existing knowledge base of the application domain. Artefact originality is a defining characteristic of DSR which makes the new artefact an innovation to the field of application.

Hevner et al. (2004) further developed the IS design perspective by developing a holistic framework for IS research – from the perspective of DSR. Hevner determined the necessary functions of IT artefacts according to given requirements with the behavioral science perspective that explains and predicts the ways the artefacts are used. He tried to reconcile the constraints of prevailing IS research activities extant at that time that either focus on design of IT artefacts or their use practices in organizations separately. In this view, the design activity is conducted iteratively, consisting of activities such as elaborating relevant problems in the application domain, building the artefact and evaluating its performance. As a result of design research, the artefact needs to satisfy the articulated requirements within a field of application as well as to enlarge the knowledge base of the scientific community.

As discussed above, design science creates and evaluates IT artefacts intended to solve identified organizational problems. Such artefacts are represented in a structured form that may vary from software, formal logic, and rigorous mathematics to informal natural language descriptions. The rich phenomena that emerge from the interaction of people, organizations, and technology may need to be qualitatively assessed to yield an understanding of the phenomena adequate for theory development or problem solving (Klein & Myers 1999). As field studies enable behavioral-science researchers to understand organizational phenomena in context, the process of constructing and exercising innovative IT artefacts enable design-science researchers to understand the problem addressed by the artefact and the feasibility of their approach to its solution (Nunamaker et al. 1991).

4.3 Design Evaluation

Because design is inherently an iterative and incremental activity, the evaluation phase provides essential feedback to the construction phase as to the quality of the design process and the design product under development. Pries-Heje et al. (2008) analysed a broad range of evaluation strategies, which includes ex ante (prior to artefact construction) evaluation. This broader view was developed as a strategic DSR evaluation framework, which expands evaluation choices for DSR researchers, and also adds emphasis to strategies for evaluating design processes in addition to design products, using well-known quality criteria as an important asset. The framework encompasses both ex ante and ex post orientations as well as naturalistic settings (e.g., case studies) and artificial settings (e.g., lab experiments) for DSR evaluation.

There is wide agreement that in design science the role of artefacts is to address unsolved problems. It is also wide agreement that in Design Science artefacts are evaluated with respect to the utility provided in solving problems. Many articles related to DSR have argued that the utility, quality, and efficacy of a design artefact must be rigorously demonstrated via well-executed evaluation methods. The development of useful artifacts is a core requirement of design science (Iivari, 2007; Peffers et al, 2007 ; Hevner & Chatterjee 2010). There is also the legitimisation of the practical utility of artifacts that relies on systematic and rigorous evaluation approaches to determine their functionality in organisations context of work, usefulness and ease of use (Peffers et al., 2007). According to Winter (2008:1), design-oriented IS research is aimed at the construction of 'better' IS-related problem solutions. Utility for practice is established as a clear and common measure of its results' relevance, but, the rigor of its construction and evaluation varies. A design artefact is complete and effective when it satisfies the requirements and constraints of the problem it was meant to solve (Simon 1996). Venable (2006) had previously identified "solution technology invention" as the core of Design Science. Design science research is described as activities that invent or build new, innovative artefacts for solving problems or achieving improvements. In this sense design science research creates new means for achieving some general (unsituated) goal, as its major research contributions. Such new and innovative artefacts create new reality, rather than explaining existing reality or helping to make sense of it.

The design activity can thus be seen as a discipline aimed at developing knowledge about the processes of giving form, about the processes of creating ideas, and about the design process as it proceeds from idea to design result (Brattleteig 2007). Carlsson (2010) also stresses the broader context of design and use as important for both the design ideas and the material-discursive practices developed during design. Carlsson (2010) states that the aim of IS Design Science research is to develop practical knowledge for the design and realization of 'IS initiatives' or to be used in the improvement of the performance of existing IS—something that the author claims had been the latter excluded by Hevner et al. (2004). By an IS initiative Carlsson means the design and implementation of an intervention in a socio-technical system where IS (including IS artefacts) are critical means for achieving the desired outcomes of the intervention.

A goal of DSR in IS is therefore, to develop practical design knowledge to be used to solve classes of IS problems. The knowledge is abstract in the sense that it is not a recipe for designing and implementing a specific IS initiative for a specific organization. A user, for example, an IS professional, of the abstract design knowledge has to 'transform' the knowledge to fit the specific problem situation and context. This is consistent with Livari and Venable's perspective that design research involves the analysis of the use and performance of designed artefacts to understand, explain and very frequently to improve on the behavior of aspects of Information Systems (Livari & Venable 2009).

The discussion above demonstrates the importance of utility and practical relevance in design science research. In addition Schön stressed the importance of constructs in providing the language in which problems and solutions are defined and communicated (Schön 1983). This highlights meaning and interpretation of constructs and its related models and methodologies. Constructs itself are described on a syntactical level. In order to structure the three elements, in this paper we propose the semiotic framework (Stamper 1973) as analytic tool that suggests different abstraction levels. Although the framework has been later extended (Stamper 1994) we focus initial on the 3 semiotic levels of syntax, semantic and pragmatic (Liu 2000; Stamper 1973). Furthermore we employ quality criteria to describe the various semiotic levels. Numerous discussions related to quality show that defining quality is at least as complex as the term design or utility. One approach, which is widely accepted in quality literature, is focused on the consumer and the product's fitness for use (Juran 1998). We follow this view of quality, in order to highlight the importance of relevance in design science. As an example of quality framework, we employ in this paper a prominent information quality framework with its 16 criteria (Wang & Strong 1996). The criteria are categories on the three semiotic levels as illustrated in Table 1.

Semiotic Level	Evaluation Criteria
Pragmatic	Relevance, usability, completeness (for organization), timeliness, actuality, efficiency
Semantic	Precise definitions and terminology, easy to understand, interpretability, accuracy (free-of error), consistent content
Syntax	Consistent and adequate syntax, syntactical correctness, consistent representation, accessibility

Table 1. Design Evaluation Framework

5 The IT-Capability Maturity Framework

5.1 Design process and Evaluation within the IT-CMF

The design process and artefact development for the IT CMF is divided into four phases separated by stage reviews with key deliverables at each stage. As indicated in Figure 1 at phase 1 references relating to the artefacts are consulted and expanded with input from group of key opinion leaders, subject matter experts, industry and academic literature. At phase 2 comparisons are made with artefacts in industry frameworks and industry best practices. At phase 3 the artefacts are reviewed with 3-5 external organisations and key opinion leaders. At phase 4 the artefacts are exercised through field experiments in at least three organisations.

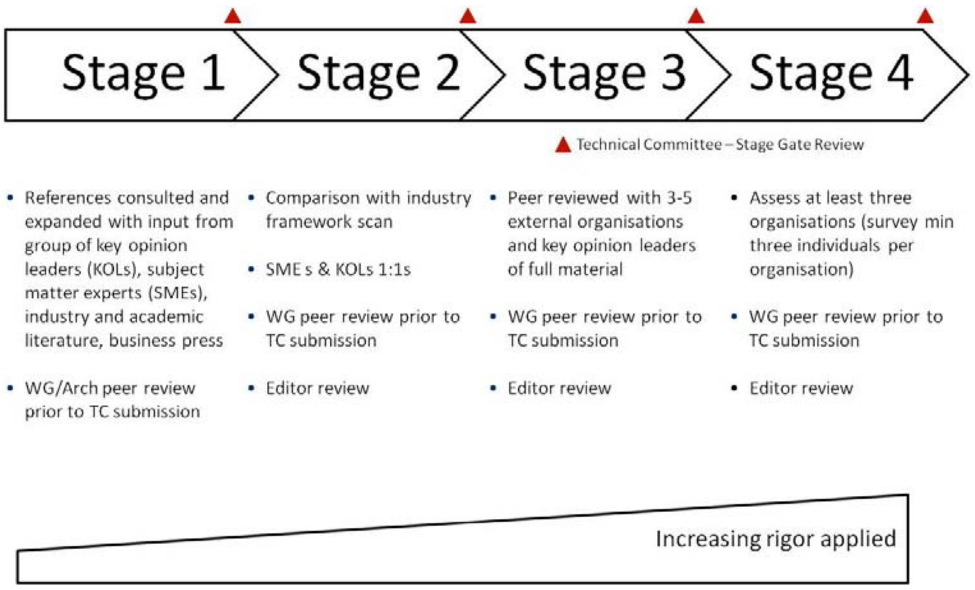

Figure 1: IT-CMF Design Process

5.2 Design Output within the IT-CMF

This research is being undertaken in conjunction with the Innovation Value Institute (www.ivi.ie). Applying the principles of engaged scholarship (Van de Ven 2007, Mathiassen and Nielsen 2008) and DSR (see above), IT Management is being investigated using a design process with defined review stages and development activities based on the DSR guidelines advocated by Hevner et al. (2004). During the design process, researchers participate together with practitioners and subject matter experts within research teams to capture the views of key domain experts. Becker et al. (2009) have described a similar design process in detail; however, for the IT-CMF we needed to adapt an engaged scholarship design process to cater for constraints often faced when working in collaboration with practitioners. The output of the design process is the IT-CMF maturity model, which contains models and assessment techniques as design artifacts.

5.3 Design Evaluation within the IT-CMF

The proposed evaluation framework described in Table 1, was applied to the review stages of the IT-CMF together with indications for measuring techniques. This is illustrated in Table 2. Core element of the framework is a set of relevant quality characteristics (adopted from Wang & Strong 1996). These characteristics are classified on the three levels of semiotics and the two aspects of quality. As an indication, we included based on the evaluation characteristics and the three levels of semiotics general measurement approaches within our framework. Some evaluation methods which could be employed to execute the measurement approach are observational, analytical, experimental, testing failures and identify defects in artefacts (Schön 1983). In addition, evaluation approaches and measurement techniques must be rigorously appropriated.

Semiotic Level	Measurement Approach	Main Review stage
Pragmatic	Application of IT-CMF Artefacts within an organizational environment	3 & 4
Semantic	Comparison with real world, experiences and verification by domain experts	2 & 3
Syntax	Consistency with Templates, syntactical standards and agreements, Proof reading Accessibility	1-4

Table 2. IT-CMF Evaluation Framework

6 Concluding Remarks and further Research

The work presented in this article examined the design and evaluation process to develop and validate the IT Capability Maturity Framework. Based on information quality we presented a framework emphasizing criteria to evaluate design artefacts. Although we believe our research provides a valuable contribution for other Design Science work, the research in this article could only provide an overview of the evaluation framework and the general design process. Indeed in our further research we aim to detail the design steps and evaluation techniques along the specific evaluation criteria. Another route for further research is the further development and improvement of the IT-CMF. As presented, the principles of design science and engaged scholarship have illustrated the benefits and thus will assist us in our future work on the IT-CMF.

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