# A NEW CONCEPTUALISATION OF DESIGN SCIENCE RESEARCH FOR DSS DEVELOPMENT

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## Abstract

*Despite a well-established research tradition, the field of Decision Support Systems (DSS) suffers from a lack of practitioner relevance. DSS researchers have comprehended the emergence of Design Science Research (DSR) for the issue as it provides support to improve the behavioral aspect of design. However, conceptualizations for DSR as the common approach to conducting DSS research have not been materialized to address the relevance issues.*

*In the paper extending an existing conceptualization, we introduce a new DSR view for DSS development. The view incorporates design dimensions related to DSS design, such as professional value, interaction, intentions, practices, and problem-solving. We developed the DSR view from an action design research approach conducted through a well-defined framework for developing a generic DSS solution. The view represents the importance of practitioner's centric DSR to better address practitioner's relevance issues in DSS design.*

***Keywords:*** *Design Science Research, Construction Centric DSR, Human Centric DSR, DSS*

## 1. Introduction

With its dedication to improving decision-making processes and practice through the application of appropriate technologies, Decision Support System (DSS) research has established a well-recognized tradition within Information Systems (IS) research. Despite its many advances and now well-established literature, DSS research is argued to lack of practitioner relevance, with the resultant DSS often criticized for a lack of relevance of practitioners and therefore resulted in poor uptake or disuse (Meensel et al. 2012; Miah, Kerr and von-Helens, 2014; Miah et al. 2008). Recent DSS literature has identified significant needs to improve quality and relevance of DSS development, particularly to achieve better engagement of industry, DSS designers and decision makers (Hosack et al., 2012; Arnott and Pervan, 2012; Arnott, 2006). Although Arnott and Pervan (2014) indicated a significant increase in the use of design science research (DSR) in recent DSS designs, the studies rarely come up with methodological and conceptual improvement in DSS DSR to achieve quality and practitioners relevance in DSS development. It is, therefore, essential task to identify comprehensive DSR view that may offer better guidance to DSS designers and IS researchers in designing more collective IS such as the DSS artefact.

In 2012, the Journal of Information Technology (JIT) published one of our papers (McKay, Marshall, and Hirchheim, 2012) that argued for a broader, more holistic conceptualization of design in IS in which both behavioral and technical design components were to be recognized and better integrated as appropriate to achieve better design outcomes. Such conceptualization would identify the need for DSR that in addition to notions of product and function well catered for in the guidelines of Hevner et al. (2004), there was a need for a focus on more immaterial notions such as systems, processes, organizations, user knowledge and experiences, on-going interactions, relationships and the situated meaning of things (McKay et al. 2012; Stewart 2011). McKay et al. (2012) suggested criticisms of DSR orthodoxy and demonstrated the breadth of ways in which IS design could be conceived and hence, the type of research that could be conducted. An argument was articulated suggesting that both construction-centric (CC) design [1](focusing largely on technical build-related activities) and human-centric (HC) design perspectives that placed emphasis on organization, people and the context of use and content of the design artefact together might better inform design activities and result in research outcomes that achieved more practical uptake than a focus purely on CC DSR.

Motivating from the argument, we develop a practitioner-centric view of DSR that combines both views of CC and HC, where the DSS design is considered as collective design to promote active engagement of practitioners for creating and recreating their specific and context sensitive DSS functionalities. This conceptual view develops via an action design research (ADR) by Sein et al. (2011) involving two disparate DSS development projects in which practitioners were closely involved throughout the design and development phases. Our contribution as a result of this research is, the DSR view that is offered for further similar DSS artefact design, especially when it is important to incorporate a variety of contextually-sensitive and localized hard and soft factors strengthening the practitioners relevance of the DSS artifact.

The paper is organized as follows. Background section describes important literature of the target issue within the perspective of DSS design science research. The section after that defines research methodology for conducting the two DSS development studies. Next section describes findings from the studies and contrasting of them to focus on the unique need of the design view. Finally, the discussion and conclusion section represents overall discussion and contributions of the proposed DSR view and how it may overcome the target issue of professional relevance in DSS design.

## 2. Background

As a class of IS DSSs are well-known IT-based systems that are intended to *"support decision-making, not replace the person in the decision-making process" (*Arnott and Pervan, 2012, p. 925), with the suggestion that DSS design should *"proactively impact the process of decision making as well as the outcome, by providing for example, real time response, distributed architectures and autonomous behaviour to support the decision makers"* (Phillips-Wren, Mora, Forgionne and Gupta (2009, p.643). They have been developed to provide options or alternatives to the DSS user, with the intention of facilitating effective decision-making within complex, structured, semi-structured, and unstructured problem domains. Since their inception, DSS solutions have been designed to assist in various activities: originally, DSS were applied to fairly structured decision making and planning in business operations (Holt and Huber, 1969); business planning (Scott Morton, 1971), and strategic planning improvement (Sprague and Carlson, 1979). With technological advance, more current DSS have been designed for various managerial support services (Klein and Methlie, 1995), including data-driven forecasting, real-time analytics (Watson, 2005) and big-data and predictive analytics (Gandomi and Haider, 2015). As the big-data phenomenon becomes more important to organizations and individuals, DSS pay a critical role in providing a usable view of the analytic methods applied to analyzing different user generated data (Gandomi and Haider, 2015), leveraging huge volume of largely heterogeneous, unstructured data and ensuring that decision makers can gain insights through their queries (Bousequet, Fomin and Drillion, 2011). The current explosion of interest in big-data analytics (Gandomi and Haider, 2015) is an indicative of the growing need for rigorous and relevant DSS design research in IS.

Although DSS have been generally successful in meeting the decision support requirements of practitioners, they do not always offer effective support and the desired outcomes for their target audience (Arnott and Pervan, 2005; Hosack et al. 2012; Arnott and Pervan, 2012). Problems in end

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[1] CC view is useful when the IT artifact is of interest to the DSR researcher. The knowledge, insights and skills revealed by a DSR researcher collectively build a science of design. But the IT artifact may be then implemented into an organizational or socio-technical context. These artifacts in the organization may become of interest to the IS researcher working in the behavioral science paradigm. Such artifacts are seen as 'surrounded' by human and organizational contingencies, HC view is of paramount important when such artefact design and seeking relevant design knowledge are of our interest (McKay et al. 2012).

user adoption and use are most prevalent in what are called 'Personal DSS'[2] (Arnott and Pervan, 2008) as the design of personal DSS is crucial to its meeting the specific requirements of individual decision makers. Many of the failures of DSS design have been attributed to inappropriate design methods that do not adequately involve stakeholders and their own reality in the design process, a mismatch between end user and designer motivations, and inadequate implementation approaches (Arnott & Dodson, 2008; Arnott and Pervan, 2012; Miah et al. 2014; Miah et al. 2009). For example, in studies in the various sectors, DSSs were not widely used among the intended end users primarily because of either a lack of familiarity with the system functions, a mismatch of requirements between end users and DSS designers in terms of the DSS outcome or process (Miah et al. 2014; Meensel et al. 2012; McCown et al. 2006), or inadequacies due to a lack of appreciation of complexities of the context of use (Arnott, 2006; Miah et al. 2009; Miah et al. 2008). Relating to the mismatching issues our focus in this paper will be centered on personal DSS design.

Hevner et al. (2004) defined DSR through distinguishing design sciences from natural sciences that enhance the state-of-the-art of artificial sciences. As the IS artefact design knowledge, insights, and skills revealed by a design researcher are collectively developed, McKay et al. (2008, 2007) called for re-conceptualizing the current technology centric design as it seems that Hevner et al. (2004) conception of IS embraces abounding of the IT artefact from other essential components together from behavioral, organizational and social context. Therefore, McKay et al. (2012) broadened Hevner's two paradigms (of design) as CC and HC DSR. Conceptualization of design science promoted by Hevner et al. (2004) has been called the *"IT design science research school"* (Carlsson, 2007, p.213). A technological focus and the view centered to IT artefact for innovation excludes numerous soft factors that result in lack of collective details of design problems as it has been theoretically demonstrated (McKay et al. 2012). Iivari (2007) criticized that Hevner et al.'s (2004) pragmatism, arguing that IS development in design science must be grounded in better theories and ontologies, going beyond a mere method for innovative artefacts design.

Leading to innovative collective artifact design, an alternative conceptualization is led by McKay et al. (2012) mainly based upon Iivari, 2007; Carlsson (2006, 2007), Niehaves and Becker (2006), and Niehaves (2007). The conceptualization stands on *"the primary interest of Information Systems lies in IT applications and therefore Information Systems as a design science should be based on a sound ontology of IT artefacts and especially of IT applications"* (Iivari, 2007, p. 56). Further to this, Iivari (2007) argued that the IS in DSR builds from IT meta-artefacts that support a concrete IT application development. This implies that a collective view of IS artefact design can reinforce quality by creating an effective design to meet the needs of the users as well as being able to fulfil the process, users and situational requirements within organizations. The conceptualization through this direction is known as more social and human-centered design aspects that have been re-iterated in a IS design form called socio-technical design aspect (Mumford, 1995; Orlikowski, 2001). In a relatively recent study Sein et al. (2011) proposed ADR as an approach to design research that assumes building the artifact is *"interwoven"* with organizational deployment and evaluation. They note in passing that their ADR approach essentially articulates what others "serendipitously" do in practice, and their main focus is on detailing an appropriately relevant and rigorous research method for this. This conceptualization seems more relevant to DSS design as a noble DSS design requires a clear concept of the nature of the decision problems as well as a well-defined strategy of how to adequately support the decision process facilitating professional's demand for decision support within an organizational context (Arnott, 2006).

## 3. Methodology

Through the framework of two DSR strategies by Iivari (2015), we described our two design cases and reflection of learning to develop on how we distilled knowledge to outline a set of design dimensions for developing the new conceptualization for DSS DSR. To guide our process of DSS artefact design, combining two DSR strategies was of paramount importance. According to Iivari

[2] PDSS that is dominated as 47.2 percent of DSR DSS articles (Arnott and Pervan, 2012). The PDSSs are usually small-scale DSS systems that are developed for one manager or a small number of independent and individual managers in order to support their decision making. Arnott and Pervan (2012) suggested that this type of DSS can be the oldest DSS type, as they remain important, especially in the form of user-built models and data driven approaches.

(2015) first, a researcher constructs an IT meta-artefact as a general solution concept to address a class of DSS design problem. Then in the second strategy, a researcher attempts to solve a client's specific problem by building a concrete IT artefact in that specific context and distilling from that *"experience prescriptive knowledge to be packaged into a general solution concept to address a class of problem"* (p.107). It implies that the identified problem of decision making must be similar in nature so a general solution concept can be drawn out of the design study. However, under the second strategy (strategy 2) we first developed a DSS artefact for the dairy business practitioners and then by applying the concept we re-constructed a DSS artefact for forestry pest industry through the ADR (Sein et al. 2011). The meta-artefact as a general solution concept helped us to outline key features of the new DSR concept for DSS design (e.g. our PODS). In this paper, we considered these two cases (dairy and forestry pest decision making) from the perspective of their potential contribution to DSR, in terms of generating the new design conceptualization from the meta-artefact design.

The two empirical design cases on which this paper is based on constructing the DSR view represent an example of a Strategy 2 approach being adopted in the first case, that enabled the learning and the meta-design to be evolved, followed by a Strategy 1 approach in the second case, through which the meta-design were further refined and evaluated. In each of the phases of the ADR cycle, we were mindful of the need for close collaboration, joint approaches to problem solving, interaction, value creation and co-design of the evolving DSS artefact, as we concur that the requirement of jointly applying HC view with CC view can be of importance in DSS DSR specifically to achieve greater relevance. Sein et al. (2011) defined ADR for achieving deeper practitioner's engagement in each cycle to describe design research efforts that assist generate design knowledge when the primary source of innovation centered to the problem context, that is, organization-dominant Building, Intervention and Evaluation (BIE) rather than IT-dominant BIE. BIE of the ADR approach draws on three principles: reciprocal shaping, mutually influential roles, and authentic and concurrent evaluation. Together these principles emphasize the inseparability of the domains for a collective artefact design (Sein et al. 2011).

*ADR Cycle 1: DSS for Dairy Farmers*

We followed the recommended stages closely for the first ADR cycle in the Dairy DSS case. For problem formulation, definitions of the target decision-making problems were outlined from the case context. In investigating the reasons perceived for the 'failure' of existing DSS, there emerged a number of process-related issues: only the scientific knowledge of the domain experts (agricultural scientists) had been included in the knowledge base, the practitioners (dairy farmers) had not been involved in the design of the system, and practitioners could not tailor the implemented DSS in response to local conditions. The DSS had been designed and built without reference to the contexts in which it was to be embedded. Our analysis of the criticisms expressed by the practitioners' revealed three persistent themes: the DSS needed to meet their practical concerns, it needed to be comprehensible to them, and it needed to be configurable to cater for environmental variations. Thus, specific characteristics of this field problem (an instance of a problem class) emerged and researchers realized the potential of building design knowledge for this class of problem.

In the Building, Intervention and Evaluation (BIE) phase, the concerns by both domain experts and practitioners formed the basis of our approach to the design of the new DSS. A key requirement was to allow for configurability, and customizability in response to localized variability, thus resulting in multiple unique instances of the artefact in use, while ensuring the integrity of the overall system. Science has well-established causal models to explain the impacts of seasonal variability (temperature, rainfall and humidity) on the moisture and fibre content in grasses (Chamberlain, 2006). At the final focus group, all participants were given an opportunity to provide feedback on both the final DSS artefact and the design process. In relation to Reflection and Learning, we took extensive notes on feedback from participants, and via facilitated focus groups and individual meetings, we jointly reflected on and started to evolve a clearer understanding of their concerns and requirements. Elements that were crucial to the design activities became evident as we interacted with DEs and practitioners. From our reflections and discussion, we articulated meta-requirements of the 'dairy' DSS but were also mindful of the emerging meta-design and design principles. Firstly, the defined decision problem was semi-structured, in that some specific factors were well known (the scientific knowledge of the DEs for example), while other aspects relied on human judgment and tacit knowledge, or were not completely understood (the impacts of local contextual variability, for example). Secondly, for aspects of the problem, scientific knowledge expressed in the form of rules could be identified as the basis for decision support. Thirdly, practitioner knowledge was of paramount importance in mediating scientific knowledge and rules and in catering for contextual distinctiveness and variability. Because of this, fourthly, knowledge sharing and translation, and joint action between the DE(s), the practitioner(s) and the DSS designer were necessary for appropriate decision support in practice. Finally, that decision support was required for decision making within dynamic contextual conditions. We summarized the design requirement from the key findings as DSS artefact must provide options for user engagement, system customization, practice orientation and knowledge sharing.

*ADR Cycle 2: DSS for Foresters*

The second ADR cycle required slight modification, as we were seeking to 'test' the meta-requirements generated from cycle 1 in a different context (strategy 1). Initial investigations revealed that the decision context was very similar in structure to that encountered in Cycle 1, and could be argued to belong to the same problem class. The system was intended to support foresters' (practitioners) decision making about pest infestations and suitable controls. Scientific knowledge of the forestry scientists (domain experts) in terms of pest identification, treatments, treatment effectiveness and advice for practitioners were elicited and stored in both text and graphic forms. As pest management knowledge is continually evolving, the DSS needed to reflect this by incorporating new knowledge from domain experts to the knowledge base to support appropriate field practice. This scientific knowledge was melded with practitioner knowledge relating to climatic and terrain influences, the efficacy of various treatments aimed at minimizing tree, leaf, and timber damage in specific locations, and the like. The decision-making context involved dynamic influences such as climate, seasonality, rainfall, maturity, type, and thus once again, configurability of the DSS by the practitioners was an important design concern. In terms of Instantiate, Evaluate, and Modify (IEM), an iterative approach was undertaken to the instantiation of the meta-artefact knowledge by domain experts and practitioners, discussion of the feedback and modification of the DSS. A prototype based on the meta-design was quickly built, and both DEs and practitioners were encouraged to experiment with this system, provide feedback, and this then was incorporated into the prototype. In the phase of Reflection and Learning, we found that the problem domain was again deemed to be semi-structured, with some well-defined applicable scientific knowledge for example. Other aspects relied on human judgment, experience, and tacit knowledge, or were not completely understood (identification of pests, the impacts of local contextual variability). However, the 'Forest' DSS relied even more on the capture and representation of scientific knowledge and practitioner knowledge to help manage the greater complexity. The dynamic contextual conditions in the field underscored the need for tailorability of the DSS by practitioners to cater for the situational requirements. In Formalization of Learning, we found that despite the increased complexity, the meta-design outlined from the Dairy DSS was entirely applicable in the forestry DSS context for meeting the decision support requirements of practitioners. Minor technical improvements were required.

# 4 Findings

Following figure 1 shows the process of drawing the design dimensions of DSS DSR out of the findings from the two design cases. The figure demonstrates findings of the design cases and the required set of design features of the DSS that was drawn from the practitioner's engagement. The design features of the DSS indicate the design dimensions defined in McKay et al. (2012) (as it is shown at the right-side in the figure 1). McKay et al. (2012) explicitly viewed professional value, intension, practice and interactions as design dimensions along with the problem solving, representing identified responsibilities to clients or designers and broader social and environmental responsibilities as a design value. This view of design emphasizes the *"situated-ness of the designer in a real-world context involving uncertainty, ambiguity and value conflict, and inevitably links design to the personal experiences, capabilities, knowledge and intuition of the designer"* (McKay et al. (2012, p.9). It implies that practitioner-oriented surroundings should have reflection built into a contextualized design process to better conceptualize and realize artefacts intended to address the target problem situation. This can assist capture of changing requirements and situational realities beyond the traditional requirements scope snapshot. Following table 1 shows a summary of the dimensions.

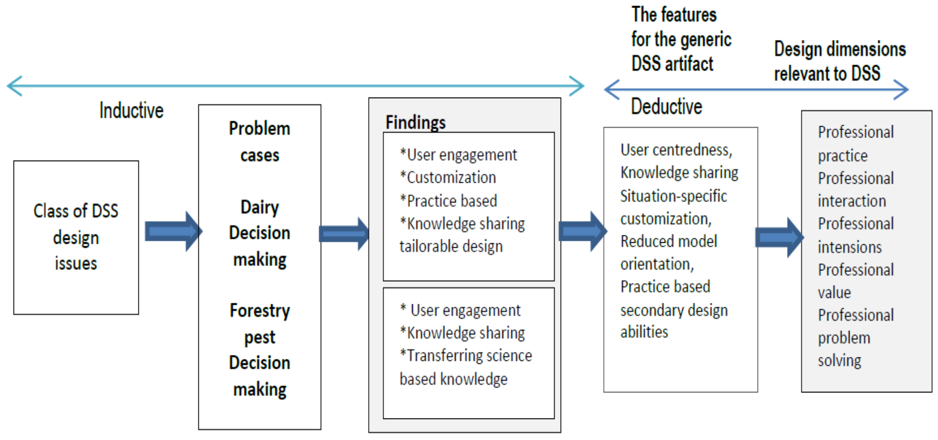


*Figure 1: Design dimensions for practitioner's oriented DSS artifact*

| *Design dimensions* | *Descriptions* | *Design needs* |
|---|---|---|
| Professional practice | Decision makers as practitioners hold responsibilities to add remove and modify their decision making contingencies through the use of tailorable features. DSS users looks forward to learning-ability through their contextualization of decision process | Reflection of practice-based knowledge |
| Professional interaction | Practitioner's interactions must be seen as key characteristics for knowledge sharing in DSS. | Requirements of knowledge sharing |
| Professional intentions | Practitioners as secondary designers are involved in a process that enables them to see connections between situations and possible solution alternatives for decision making | Features for context sensitivity |
| Professional value | Practitioners' own preferences must been seen as value that are reflected through design features within their context. | Effective meanings of decision problems |
| Professional problem solving | DSS design features that accommodate practitioner's practical consequences must be seen as a transformation in their regular problem solving methods. | problem solving through optimized rule re-creation |

*Table 1: Descriptions of the design dimensions captured from the ADR cycles*

## 5. Discussion and conclusion

The unique contribution of the paper is the new DSR conceptualization for DSS design. This study introduced the set of design dimensions in order to address issues of professional relevance in DSS design. We re-defined the existing framework of McKay et al. (2012) which was previously offered design dimensions to enhance practitioners' engagement for IS design. Beyond this work, the proposed view promoted the innovative DSS design options in terms of how the design of artefact can be seen as adding value to practitioners in meeting both organizational and practical desires. Through the five design needs, the proposed dimensions in DSR recognized the need of addressing the problem of professional relevance in artefact design as this resonates that things, technologies, people, and organizations do not have inherently determinate meanings within their boundaries (Barad, 2007). Our view is developed through the Iivari (2015) that offered strategies to incorporate design and evaluation activities to focus on the entanglement of technologies, people, and organizations for artefact design.

Iivari (2007) suggested that a design theory is not necessarily based on any scientifically validated knowledge; rather it could be based on any practitioner theory-in-use. Generating such collective knowledge in the DSS domain, artefact design may support the development of flexible DSS applications by elevating the understanding of the practitioners' work activities and the context in which they work. Such professional oriented view also resonates McKay's et al. (2012) suggestion of construction of broader design view for capturing more human-oriented realities, so both CC and HC views work together to strengthen the IS design. The focus of CC view is on the IT artefact (Carlsson, 2007) and relevant design activity, whereas HC design view is important when artifact is heavily rooted within organization context; users interact with that artifact and endow it with meaning with in that particular context of use, can be of paramount importance to effective DSS design.

## References


Arnott, D. (2006). Cognitive biases and decision support systems development: a design science approach, Information Systems Journal, 16, 55–78.

Arnott, D. and Pervan, G. (2008). Eight key issues for the decision support systems discipline, Decision Support Systems, 44(3), 657-672.

Arnott, D. and Pervan, G. (2012). Design Science in Decision Support Systems Research: An Assessment using the Hevner, March, Park, and Ram Guidelines, Journal of the Association for Information Systems, 13 (11), 923-949.

Arnott, D. R. and Dodson, G. (2008). Decision support systems failure. In F. Burstein & C. W. Holsapple (Eds.), Handbook on decision support systems, Berlin: Springer.

Barad, K. (2007). Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning, Durham, NC: Duke University Press.

Bousequet, F., Fomin, V. V. and Drillion, D. (2011). Anticipatory standards development and competitive intelligence. International Journal of Business Intelligence Research, 2(1), 16-30.

Carlsson, S.A. (2007). Developing Knowledge Through IS Design Science Research: For Whom, What Type of Knowledge, and How, Scandinavian Journal of Information Systems, 9(2), pp.75-86.

Carlsson, S. A. 2006, Design science in information systems: a critical realist perspective, Seventeenth Australasian Conference on Information Systems, Adelaide, 6–8 December.

Chamberlain, A (2006). Protein Plus Checkbook: A guide to increasing milk protein % and profit, The State of Queensland, Department of Primary Industries and Fisheries, Brisbane, Australia

Hevner, A., March, S., Park, J., and Ram, S. (2004). Design Science in Information Systems Research, MIS Quarterly, 28(1), 75-105.

Hosack B, Hall, D., Paradice, D. and Courtney, J.F. (2012) A look toward the future: decision support systems research is alive and well, Journal of the Association for Information Systems 13(5), 315–340.

Holt, C. C. and G. P. Huber (1969). A Computer Aided Approach to Employment Service Placement and Counseling, 15 (11), 573-595.

Iivari, J (2015) Distinguishing and contrasting two strategies for design science research. European Journal of Information Systems 24(1), 107–115.

Iivari, J. (2007). A paradigmatic analysis of information systems as a design science, Scandinavian Journal of Information Systems, 19 (2), 39-64.

Klein, M. and Methlie, L. B. (1995). Knowledge-based Decision Support Systems with Applications in Business. Chichester, UK: John Wiley & Sons.

March, S.T. and Smith, G. (1995). Design and natural science research on information technology, Decision Support Systems 15(4), 251-266

McCown, R.L., Brennan, L.E. and Parton, K.A. (2006). Learning from the historical failure of farm management models to aid management practice. Part 1. The rise and demise of theoretical models of farm economies, Australian Journal of Agricultural Research, 57, 143–156.

McKay, J., Marshall, P. and Hirchheim, R. (2012). The design construct in information systems design science, Journal of Information Technology, 27, 125–139.

Meensel, J.V., Lauwers, L, Kempen, I., Dessein, J. and Huylenbroeck, G.V. (2012). Effect of a Participatory Approach on the Successful Development of Agricultural Decision Support Systems: The Case of Pigs2win. Decision Support Systems 54(1), 164–172.

Miah, S.J. Kerr, D. and von-Helens, L (2014) A collective artefact design of decision support systems: design science research perspective, Information Technology & People, 27 (3), 259-279.

Miah, S.J., Kerr, D. and Gammack, J. (2009) A Methodology to allow Rural Extension Professionals to build Target-specific expert systems for Australian Rural Business Operators, Journal of Expert Systems with Applications, 36, 735-744.

Miah, S.J., Kerr, D. and Gammack, J. and Cowan, T. (2008) A generic design environment for the rural industry knowledge acquisition, Knowledge-Based Systems, 21 (8), 892-899.

Mumford, E. (1995). Effective Requirements Analysis and Systems Design: The ETHICS Method, Macmillan, London.

Niehaves, B. (2007). On Epistemological Pluralism in Design Science, Scandinavian Journal of Information Systems 19(2): 99–110.

Niehaves, B. and Becker, J. (2006). Epistemological Perspectives on Design Science in IS Research, in Proceedings of the Twelfth Americas Conference on Information Systems (Acapulco, Mexico); 4–6 August.

Orlikowski W. J. and Iacono C. S. (2001). Desperately seeking the "IT" in IT research – a call to theorizing the IT artifact, Information Systems Research, 12 (2), 121-134

Orlikowski, W. (1992). The duality of technology: rethinking the concept of technology in organisations, Organisation Science, 3 (3), 398–427.
Orlikowski, W. J. (2009). The socio-materiality of organizational life: considering technology in management research, Cambridge Journal of Economics, 34, 125-141.
Phillips-Wren, G., Mora, M., Forgionne, G.A., and Gupta, J.N.D. (2009). An integrative evaluationframework for intelligent decision support systems, European Journal of Operational Research 195(3), 642–652.
Scott Morton, M. S. (1971). Management Decision Systems; Computer-based support for decision making, Boston, Division of Research, Graduate School of Business Administration, Harvard University
Sein M, Henfridsson. O., Purao S, Rossi M, and Lindgren R. (2011). Action design research, MIS Quarterly, 35 (1), 37-56.
Sprague, Jr., R. H., and Carlson. E. D. (1979). Building effective decision support systems. Englewood Cliffs, NJ: Prentice-Hall, Inc.
Stewart, S. (2011). Interpreting Design Thinking, Design Studies, 32(6), 515–520.
Watson, H. (2005). Sorting out what's new in decision support. Business Intelligence Journal, 10(1), 4-8.