Chapter 15
Design Science Research in Information Systems: A Critical Realist Approach

It is not what you say, but how you say it.
– A. Putt

Information systems research has serious utilization and relevance problems. To increase IS research utilization and relevance, scholars argue that the dominating behavioral IS research paradigm should be complemented with IS design science research. The most influential IS design science research schools have a strong focus on the IT artifact, in most cases an exclusive focus on the IT artifact. The schools have very little discussions and clarifications regarding underpinning philosophies, but most seem to be based on positivism, traditional realism, or pragmatism. This chapter presents, as a complement to the most influential design science research schools, an alternative approach for IS design science research. The approach builds on the premise that one of the most critical aims of IS design science research is to develop practical knowledge for the design and realization of different classes of IS initiatives, where IS are viewed as socio-technical systems and not just IT artifacts. The underpinning philosophy of the approach is critical realism which has been developed as an alternative to positivism and traditional realism as well as to constructivism (relativism). The developed practical IS design knowledge can be represented in different forms, for example, as heuristic design propositions, design exemplars and patterns, models or frameworks, and stories or narratives. The IS design knowledge can be developed using different methods and techniques. The chapter presents how practical IS design knowledge can be developed as well as the nature of the developed knowledge.

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15.1 Introduction

As noted in this book, we have in the last years seen an intensive debate in the information systems (IS) community on the "crisis in the IS field" – see, for example, the debates in journals like *MIS Quarterly* and *Communications of the Association for Information Systems*. Some commentators argue that part of the crisis is related to utilization and relevance problems (Agarwal and Lucas 2005; Hirschheim and Klein 2003): research not addressing relevant issues and research not producing useful and usable results. It seems that too much IS research is "method driven" and/or "theory driven" and not "problem driven." Topics are chosen not because they are important, but because they are amenable to analysis by the ruling "méthode au théorie du jour" – for a similar point but in a different field, see Walt (1999). A theme of this book is that one way to increase IS research utilization and relevance is to produce more IS design science research. As the chapters in this book testify, interesting IS design science research has been produced, but from my perspective two major issues have not been carefully addressed.

First, there is too little discussion about what IS design science research should include and exclude. This is related to the discussion about what the IS discipline ought to be and what ought to be at the core of the IS discipline. When there is a discussion in the IS design science research literature the expressed views stress that IT artifacts and IT design theories should be developed. I have no problems with this, but I think the views are too narrow and they need to be complemented. In fact, Simon's (1988) view on design science shows that it can be more than IT artifacts and IT design theories that the IS field should develop. I will argue that there is a need for IS design science research approaches having a broader view on IS and IS design knowledge.

Second, there is no, or little, discussion about underlying philosophical assumptions in the IS design science research literature. Purao puts it most elegantly: "...the scientific foundations underlying this critical area of the IS field – design research – have remained largely undeveloped. ... Over the years, in spite of important writings about research (e.g., March and Smith 1995), philosophical underpinnings of this form of research have been largely unexplored. Without adequate scientific foundations, research in the technology of information systems (TIS) continues to be a lost child still searching for its scientific home" (Purao 2002). The underlying ontological view an IS design science research framework or approach is built on will ultimately affect how to do IS design science research and what types of outcomes that can be produced. Although current frameworks and approaches to a large extent lack in clearness on underpinning philosophies and ontological views, they seem to be based on positivism, traditional realism, or pragmatism. In behavioral IS research there is an increased and fruitful use of alternative philosophies, for example, the use of constructivism. Consequently, I suggest that it can be fruitful to develop and explore IS design science research frameworks and approaches based on alternative philosophies, that is, frameworks and approaches based on alternative ontologies and epistemologies.

Hence, the aim of this chapter is to present an alternative IS design science research approach. The underpinning philosophy of the approach is critical realism.

The remainder of the chapter is organized as follows: the next section elaborates the above two issues. The section argues for a broader view on IS design science research and for grounding IS design science research in the philosophy of critical realism. A presentation of critical realism follows and this is followed by a presentation of an IS design science research approach based on the philosophy of critical realism. Guiding my work is what I call the idea of the triple hurdle: IS design science research should *meet the criteria of scholarly quality*, *address practical (professional) issues and problems*, and *generate practical design knowledge*.

15.2   Why an Alternative Information Systems Design Science Research Approach?

Two major IS design science research schools have emerged (El Sawy, O.A., Personal communication, August 2006): (1) the Information Systems Design Theory school (Gregor and Jones 2007; Walls et al. 1992, 2004) and (2) the Design Science Research school (Cao et al. 2006; Hevner et al. 2004; March and Smith 1995; Nunamaker et al. 1990–91). The schools are introduced in Chapter 1. Below I briefly review these schools by primarily focusing on two issues: (1) what is focused in the IS design science research schools and (2) what underlying philosophies – for example, ontological and epistemological views – have the schools. The first issue is related to the discussion on what the IS discipline ought to be and what ought to be at the core of the discipline. The second issue is critical since in all research, including IS design science research, ontology is non-optional (Trigg 2001).

One of the first, if not the first, article on developing IS design theories (ISDT) and IS design knowledge was published in 1992 by Walls et al. (1992). Walls et al. argue that successful construction of ISDT would create an endogenous base for theory in the IS discipline and could be used by scholars to prescribe design products and processes for different classes of IS as they emerged. The authors build on Simon's distinction – natural science and sciences of the artificial – and argue that design is both a *product* and a *process*, which means that a design theory must have two aspects: one that deals with the design product and one that deals with the design process. Using their framework the authors propose an ISDT for the IS-class "vigilant information systems." The components of an IS design theory are summarized in Table 15.1.

Walls et al. use the concept "artifact" quite freely, but in reflecting on their 1992 paper they say "We did not use the current phrase 'IT artifact', but in essence it was that to which we were referring" (Walls et al. 2004). Walls et al.'s work was extended by Gregor and Jones (2007). They extended and clarified Walls et al.'s ISDT and identified eight separate components of design theories: (1) purpose and scope, (2) constructs, (3) principles of form and function, (4) artifact mutability, (5)

Table 15.1 Components of an IS design theory (Walls et al. 1992)

Design product	
1. Meta-requirements	Describes the class of goals to which the theory applies
2. Meta-design	Describes a class of artifacts hypothesized to meet the meta-requirements
3. Kernel theories	Theories from natural or social sciences governing design requirements
4. Testable design product hypotheses	Used to test whether the meta-design hypotheses satisfy the meta-requirements
Design process	
1. Design method	A description of procedure(s) for artifact construction
2. Kernel theories	Theories from natural or social sciences governing design process itself
3. Testable design process hypotheses	Used to verify whether the design hypotheses method results in an artifact which is consistent with the meta-design

testable propositions, (6) justificatory knowledge (kernel theories), (7) principles of implementation, and (8) an expository instantiation.

Building on Simon's work, March and Smith (1995) distinguish between design sciences and natural sciences. The former involves building and evaluating (1) *constructs* which are "concepts with which to characterize phenomenon," (2) *models* that "describe tasks, situations, or artifacts," (3) *methods* as "ways of performing goal-directed activities," and (4) *instantiations* which are "physical implementations intended to perform certain tasks."

Hevner et al. (2004), building on March and Smith, present a design science framework and guidelines for building and evaluating IT artifacts. Hevner et al. expressed their view on what constitutes good – rigorous and relevant – IS design science research in the form of seven guidelines. The authors contend that each of the guidelines should be addressed in some manner for IS design science research to be complete. Guideline one – "design as an artifact" – says "Design-science research must produce a viable artifact in the form of a *construct*, a *model*, a *method*, or an *instantiation*" (Hevner et al. 2004, italics added to indicate similarity with March and Smith's view on the output of design science research). And, the "result of design-science research in IS is, by definition, a purposeful IT artifact created to address an important organizational problem. ... Our [Hevner et al.'s] definition of IT artifacts is both broader and narrower [than other IT artifact definitions] ... It is broader in the sense that we include not only instantiations in our definition of the IT artifact but also the constructs, models, and methods applied in the development and use of information systems. However, it is narrower in the sense that we do not include people or elements of organizations in our definition nor do we explicitly include the process by which such artifacts evolve over time." The Hevner et al. framework is further elaborated in this book.

Regarding what should be included in an IS design research framework, and consequently in IS design theory and IS design knowledge, it is clear that Walls et al., March and Smith, and Hevner et al. focus on the IT artifact. They exclude

the non-technological context by excluding people and organizations. Given the schools' focus and what they exclude, the schools might better be named IT design science research schools.

There is a lively debate in the IS community on what constitutes the "IS core" – see, for example, the debate in *Communications of the Association for Information Systems*, especially volume 12 (2003). Benbasat and Zmud (2003) suggest that the core of the IS discipline and IS research should be the IT artifact. I consider this a narrow view on the IS discipline and IS research. Alter (2003) suggests a broader view and argues that the core of the IS discipline should be "work systems." In the IS core debate, Myers (2003) argues for that the IS discipline is nowhere near ready to define an IS core – he argues for open, flexible, and adaptive views. Hence, he argues for broad and emergent views on the IS core. Said Myers: "I believe that diversity is a positive attribute and ensures the continued viability of the field in a rapidly changing environment" (Myers 2003). I agree with Myers. The above IS design science research schools have views more in line with Benbasat and Zmud's view than with Alter's and Myers' views. It should be noted that Walls et al. and Hevner et al. say that IS design theories and frameworks can encompass more than the IT artifact. Furthermore, Hevner et al.'s second design guideline – problem relevance – states "The objective of design-science research is to develop technology-based solutions to important and relevant business problems" (Hevner et al. 2004). It is noteworthy that lists, based on business needs, of current and future critical IS issues, for example, lists published by the Gartner Group, often have "non-technological" issues as the most critical (relevant) and less easy to solve problems like "how to align our business strategy and IT strategy."

My view is that an IS design science research framework or approach should be explicit on what should be produced, for example, design knowledge, artifacts, or artificial IS. I suggest that one of the most critical aims 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. By an IS initiative I mean the design and implementation of a solution in a social–technical system where IS (including IT artifacts) are critical means for achieving the desired outcomes of the intervention. My IS initiative view is in line with Alter's (2004) and Agarwal and Lucas' (2005) views. Agarwal and Lucas (2005) argue that IS research to become more relevant needs to have a more macro-oriented focus and should address the transformational impact of information technology and IS, that is, a focus on how information technology and IS can be used to change (transform) an organization or a network of organizations.

The second issue I address is the underpinning philosophies of IS design science research approaches and frameworks. The above-discussed IS design science research schools do not explicitly address ontology, but ontology is non-optional in all research (Fleetwood 2004). Although the above schools do not address underpinning philosophies and ontologies, it is possible to conclude that they are based in positivism, traditional realism, or pragmatism. This conclusion is based on the few philosophical and philosophy of science references used by the authors and that they use concepts like "prove." Hevner et al. explicitly refer to pragmatism and

Cole et al. state that "..DR [Design Research] is rooted in pragmatism" (Cole et al. 2005). Arnott and Pervan (2008) reviewed the DSS discipline, which is a discipline where design science research is central and where a lot of novel artifacts are developed. They found that a fairly large amount of DSS research was design science research (a much higher proportion than for most other IS areas). They also found that DSS research is overwhelmingly dominated by positivism and that 92.3% of the empirical studies in their review were based on positivism.

It is noteworthy that the ISWorld web site on "Design Research in Information Systems" has a section on the "philosophical grounding of design research" (Vaishnavi and Kuechler 2004/5). Unfortunately, the authors mix concepts and definitions and their use of key concepts are inconsistent with what can be found in philosophy of science. For example, they say that "ontological and epistemological viewpoints shift in design research as the project runs through circumscription cycles ... This iteration is similar to but more radical than the hermeneutic processes used in some interpretive research" (ibid.). This means that in IS design science research a researcher's assumptions about how the world is "constructed" and what exists should change during a design science research project. What the authors probably mean is that our knowledge of the world changes which is quite a different matter. They also make what Bhaskar (1975/1978) calls an "epistemic fallacy" in that they transpose what is an ontological matter – concerning what exists – into an epistemological matter of how to develop reliable knowledge about the world. It is interesting to note that the authors make a reference – using Mario Bunge's work – to critical realism: "Bunge (1984) implies that design research is most effective when its practitioners shift between pragmatic and critical realist perspectives, guided by a pragmatic assessment of progress in the design cycle" (Vaishnavi & Kuechler 2004/5). Unfortunately, they do not explore Bunge's view.

To summarize, writings on IS design theory, IS design knowledge, and IS design science research almost never explicitly discuss ontological issues and underpinning philosophies, but most papers (work) seem to be based in positivism, traditional realism, or pragmatism. This is consistent with studies on research in the IS field. The overwhelming majority of research is based in positivism (Chen and Hirschheim 2004). IS research commentators point out weaknesses in positivism, etc., and suggest the use of alternative philosophies, like constructivism. This chapter presents an IS design science research approach based on the philosophy of critical realism, which is an alternative to positivism as well as to constructivism. Critical realism is presented in the next section.

15.3 Critical Realism

Different philosophies of science have different ontological views. Idealists have the view that reality is not mind-independent. Idealism comes in different forms reflecting different views on what is man-created and how it is created. Realists have the view that reality exists independently of our beliefs, thoughts, perceptions,

discourses, etc. As for idealism, realism comes in different forms. Today most philosophies of science are based on realism. Bhaskar says that it is not a question of being a realist or not, but what type of realist (Bhaskar 1991).

Critical realism (CR) was developed as an alternative to traditional positivist models of social science and as an alternative to post-approaches and post-theories, e.g., constructivism and structuration theory. The most influential writer on critical realism is Roy Bhaskar. Unfortunately, Bhaskar is an opaque writer, but good summaries of CR are available in Archer et al. (1998), Sayer (2000), Dean et al. (2005), and Chapter 1 in Bhaskar (2002); key concepts and main developments are presented in Hartwig (2007). In Archer et al. (1998) and Lòpez and Potter (2001), chapters focus on different aspects of critical realism, ranging from fundamental philosophical discussions to how statistical analysis can be used in CR-based research.

Critical realism was primarily developed as an answer to the positivist crisis. In 1975 Roy Bhaskar's work "A Realist Theory of Science," with "transcendental realism," was published. In "*Possibility of Naturalism*" Bhaskar (1979/1998) focused the social sciences and developed his "critical naturalism." These two major works present a thorough philosophy of science project and later "critical realism" and "critical naturalism" were merged to "critical realism," a concept also used by Bhaskar. Through the 1980s Bhaskar primarily developed his position through sharpening arguments, etc. The late 1970s and early 1980s also saw a number of other CR scholars publishing influential works, for example, Margaret Archer's "*Social Origins of Educational Systems*" (1979) and Andrew Sayer's "*Method in Social Science*" (1984/1992. Most of CRs early critique was targeting positivism, but later critique is targeting alternatives to positivism, for example, postmodernism and structuration theory. CR is a consistent and all-embracing alternative to positivism and different postmodernistic strands.

Critical realism can be seen as a specific form of realism: "To be a realist is to assert the existence of some disputed kind of entities such as gravitons, equilibria, utility, class relations and so on. To be a scientific realist is to assert that these entities exist independently of our investigation of them. Such entities, *contra* the post modernism of rhetoricians, are not something generated in the discourse used in their investigation. Neither are such entities, *contra* empiricists, restricted to the realm of the observable. To be a *critical* realist is to extend these views into social science" (Fleetwood 2002). CR's manifesto is to recognize the reality of the natural order and the events and discourses of the social world. It holds that "we will only be able to understand – and so change – the social world if we identify the structures at work that generate those events or discourses . . . These structures are not spontaneously apparent in the observable pattern of events; they can only be identified through the practical and theoretical work of the social sciences" (Bhaskar 1989). Bhaskar (1978) outlines what he calls three domains: the *real*, the *actual*, and the *empirical* (Table 15.2). The *real* domain consists of underlying structures and mechanisms, and relations; events and behavior; and experiences. The generative mechanisms residing in the real domain exist independently of, but capable of producing, patterns of events. Relations generate behaviors in the social world.

Table 15.2 Ontological assumptions of the critical realist view of science (Bhaskar 1978)

	Domain of real	Domain of actual	Domain of empirical
Mechanisms	X		
Events	X	X	
Experiences	X	X	X

X's indicate the domain of reality in which mechanisms, events, and experiences, respectively, reside, as well as the domains involved for such a residence to be possible.

The domain of the *actual* consists of these events and behaviors. Hence, the actual domain is the domain in which observed events or observed patterns of events occur. The domain of the *empirical* consists of what we experience; hence, it is the domain of experienced events.

Bhaskar argues that "...real structures exist independently of and are often out of phase with the actual patterns of events. Indeed it is only because of the latter we need to perform experiments and only because of the former that we can make sense of our performances of them. Similarly it can be shown to be a condition of the intelligibility of perception that events occur independently of experiences. And experiences are often (epistemically speaking) 'out of phase' with events—e.g. when they are misidentified. It is partly because of this possibility that the scientist needs a scientific education or training. Thus I [Bhaskar] will argue that what I call the domains of the real, the actual and the empirical are distinct" (Bhaskar 1978). Critical realism also argues that the real world is ontologically stratified and differentiated. The real world consists of a plurality of structures and generative mechanisms that generate the events that occur and do not occur. From an epistemological stance, concerning the nature of knowledge claim, the realist approach is non-positivistic which means that values and facts are intertwined and hard to disentangle.

Critical realism is a well-developed philosophy of science, but on the methodological level, it is less well developed. The writings of Layder (1993, 1998, 2005), Kazi (2003), Pawson and Tilley (1997), and Pawson (2006) as well as some of the chapters in Ackroyd and Fleetwood (2000) and Fleetwood and Ackroyd (2004) can serve as guidelines for doing critical realism research. Unfortunately, from an IS design science research perspective, the writings on critical realism have been in the behavioral science paradigm.

Critical realism has influenced a number of disciplines and fields, for example, economics, management, and organization studies. It has until recently been almost invisible in the IS field. CR's potential for IS research has been argued by, for example, Carlsson (2003, 2004, 2009), Dobson (2001), Mingers (2003, 2004), and Mutch (2002). CR-based empirical research can be found in, for example, Morton (2006), Volkoff et al. (2007), Dobson et al. (2007), and De Vaujany (2008). CR has also critical and emancipatory components (Bhaskar 2002). Wilson and Greenhill (2004) and Longshore Smith (2005) address how CR in IS research can work critically and

emancipatory. The writings on CR in IS have been focusing on the use of CR in the behavioral science paradigm and not on how it can be used in IS design science research. CR's potential for IS design science has been argued by Carlsson (2006) and Lyytinen (2008). CR-based IS design science can be found in Carlsson et al. (2008) and Hrastinski et al. (2007, forthcoming). In the next section I will present an IS design science research approach underpinned by the philosophy of critical realism.

15.4 A Critical Realist Approach for IS Design Science Research

This section presents and discusses a critical realist approach for IS design science research. I start with discussing what types of IS design knowledge should be produced and for whom. This is followed by a presentation of how IS design knowledge can be developed.

15.4.1 For Whom Should IS Design Science Research Produce Knowledge?

March argues that relevance, rigor, and results are the trifecta of academic IS research and that they are defined by the constituency that comprises and supports the IS discipline. This constituency includes "IS academic researchers, organizations that develop and deploy information technologies (IT), organizations that produce and implement such technologies, IS managers within such organizations and, more and more commonly, general and upper level managers within such organizations" (March 2006, p. 338).

My view is that one of the most important constituent community for the output of IS design science research is IS professionals and managers responsible for IS/IT-supported and IS/IT-enabled processes and activities. This means primarily professionals who plan, manage, govern, design, build, implement, operate, maintain, and evaluate different types of IS/IT initiatives and IS/IT. The design knowledge this community demands include (1) knowledge for developing IT/IS-enabled solutions (including improving previous implemented solutions) that primarily address organizational problems and (2) knowledge for how to implement and integrate the solutions into the context (primarily organizational context). The developed IS design knowledge is to be applied by individuals who have received formal education or a similar training, for example, in the IS field. An IS professional can be defined as a member of a fairly well-defined group who solves real-world IS problems with the help of skills, creativity, and scientific and non-scientific IS design knowledge. (For simplicity I call the problems IS problems although it is more correct to say that someone has defined a problem where one, for one reason or another, has decided to try to solve the problem with an IS initiative).

Another important community is IS education, which means that the knowledge should be useful in different types of IS study programs and IS courses.

Although the primary constituent community works primarily in organizations driven by "utility maximization" (often in terms of profit), it should be noted that critical realism has also critical and emancipatory components (Bhaskar 2002). Wilson and McCormack (2006) show how critical realism can work as a framework to guide appropriate action in emancipatory practice development and realistic evaluation for understanding the outcomes of those actions. The critical and emancipatory issues are far from well addressed in the IS design science research literature. The two major schools discussed above have a clear management perspective and certainly not an emancipatory or critical perspective (Stahl 2008). The emancipatory and critical issues are important. They can, for example, address issues like the development of IT artifacts for increasing democracy or the development of systems development methods for supporting resource-weak stakeholders. I note the importance of emancipatory and critical issues, but leave the issues for further exploration and development.

15.4.2 What Types of IS Design Knowledge Should IS Design Research Produce?

As discussed above, there is a lively debate in the IS community on what constitutes the "IS core." In the IS design science research literature this debate has been less lively. It seems that most writings on IS design science research have views in line with Benbasat and Zmud's (2003) view that the core of the IS discipline and IS research should be the IT artifact. As said above, I find the "pure" IT artifact view a too narrow view.

McKay and Marshall (2005, 2007, 2008) argue that IS is a socio-technical discipline and that "design science and the research that builds that body of knowledge must acknowledge that IS is fundamentally about human activity systems which are usually technologically enabled, implying that the context of ***design*** and ***use*** is critical, and that research paradigms, practices and activities must embrace such a worldview. (McKay and Marshall 2005, p. 5). Venable (2006) argues that the core of IS design science research is "solution technology invention," where "Solution technologies that are relevant in the IS/IT field include IS development methods, techniques, and tools, IS planning methods, IS management methods, IS/IT security and risk management practices, algorithms for computer processing, such as database processing, and many others, all of which are designed purposefully to address human and organisational problems and all of which must be adapted or redesigned when addressing particular, situated problems." (p. 8)

In line with McKay and Marshall's and Venable's views I suggest 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. The latter is excluded by Hevner et al. (2004), but seems to be critical for practitioners; see, for example, Bendoly and Jacobs (2005) on strategic extension and use of ERP systems. As discussed above, by an IS initiative I mean the

design and implementation of an intervention in a socio-technical system where IS (including IT artifacts) are critical means for achieving the desired outcomes of the intervention. My view is that IS design science research should include organizations, people, IS, and IT artifacts. Given some of the current technological and business changes I think such a view is appropriate. For example, many organizations are no longer viewing ERP projects as technical projects, but as major re-organization projects; and the increased use of commercial off-the-shelf (COTS) software and different forms of sourcing requires new relevant, and in part non-IT-artifact, knowledge to be developed. Further, reviewing lists of what IS/IT issues are most critical to organizations I find that most of these are managerial issues and not technological issues (Smith and McKeen 2006). Also, it can be argued that a broader view will become more fruitful as the use of IT moves from connection to immersion and fusion (El Sawy 2003). In immersion IT-based IS are immersed as part of the business environment and cannot be separated from work, processes, and the systemic properties of intra- and inter-organizational processes and relationships. In fusion IT-based IS are fused within the business environment such that business and IT-based IS form a unified fabric. Hence, IT-enabled work and processes are treated as one. Recent studies suggest that business-related IS issues are becoming more and more critical (Zwieg et al. 2006, Luftman et al. 2009). Hence, my view is that IS design science research needs to develop relevant design knowledge for this new "landscape" and not just develop IT artifacts or IT artifact design theories.

IS design science research should develop practical design knowledge to be used to solve classes of IS problems. This means the development of knowledge that can be used in designing and implementing IS initiatives. 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 of the abstract design knowledge, for example, an IS professional, has to "transform" the knowledge to fit the specific problem situation and context. Below I will present, discuss, and illustrate what types of knowledge can be produced and how this knowledge can be produced.

Following Pelz (1978), I distinguish between conceptual and instrumental use of science and research output. The former involves using knowledge for general enlightenment on the subject in question and the latter involves acting on research results in specific and direct ways. Both types are relevant for the IS field, but IS design science research develops primarily knowledge for instrumental use.

Using van Aken's (2004) classification I can distinguish three different types of designs an IS professional makes when designing and implementing an IS initiative: (1) an *object design*, which is the design of the IS initiative (including the design of an IT artifact); (2) a *realization design*, which is the plan for the implementation of the IS initiative; and (3) a *process design*, which is the professional's own plan for the problem-solving cycle and includes the methods and techniques to be used in object and realization design. IS design science research should produce knowledge that can be used by the professionals in the three types of designs, including novel IT artifacts, methodologies, methods and techniques, and socio-technical implementation knowledge. (Although I discuss in terms of an IS professional the different designs are in most cases done by groups/teams of a number of IS professional and often including non-IS professionals like IS users.) Given my broader perspective –

IS intervention in a socio-technical system – than the schools discussed above, it can be argued, based on the IS implementation and IS failure literature, that realization design knowledge is critical and hence should also be developed.

The rationale for developing IS design knowledge to be used in the three types of design is that such knowledge can support practitioners in designing initiatives which will trigger mechanisms which may lead to desired outcomes (recall the discussion above on mechanisms). Figure 15.1 – the realist IS intervention – is adapted from Pawson and Tilley's (1997) model of realist casual explanation: "IS initiative (I)" and "problem situation (P)" have been added. The success of an IS initiative will always be limited by contextual constraints.
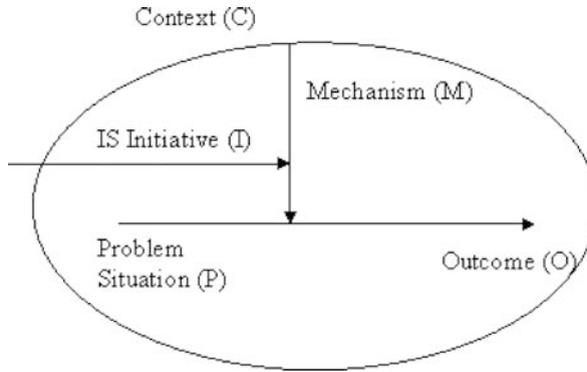

Fig. 15.1   The realist IS intervention

Using my IS design science research approach should lead to evermore detailed answers to the question of *why* and *how* an IS initiative works, for *whom,* and in *what* circumstances. Using the approach means that a researcher attends to how and why an IS initiative has the *potential* to cause a desired change. In this perspective, a researcher works as an experimental scientist, but not according to the logics of traditional experimental research. Since critical realism has an open system view and that it recognizes social systems' complexity the research will generate IS design knowledge being provisional, fallible, incomplete, and extendable.

I do not perceive that IS initiatives "work." It is the actions of the stakeholders making them work, and the causal potential of an IS initiative takes the form of providing the reasons and resources to enable different stakeholders and participants to "make" changes. This means that a researcher seeks to understand *why* and *how* an IS initiative, for example, the implementation of a CRM system, works through understanding the action mechanisms. It also means that a researcher seeks to understand *for whom* and *in what circumstances* (*contexts*) an IS initiative works through the study of contextual conditioning.

Researchers orient their thinking to problem situation (P), IS initiative (I), mechanisms (M), context (C), outcome (O) pattern configurations (PIMCO configurations). A PIMCO configuration is a proposition stating what it is about an IS

initiative which works for whom in what circumstances. A refined PIMCO configuration is the finding of an evaluation of an IS initiative. This leads to the development of transferable and cumulative knowledge. Outcome patterns are examined from a "theory-testing" perspective. This means that a researcher tries to understand what the outcomes of an IS initiative are and how the outcomes are produced. Hence, the researcher does not just inspect outcomes in order to see whether an IS initiative works, but analyzes the outcomes to discover whether the conjectured PIMCO configurations are confirmed.

IS design knowledge can be represented in many different forms, for example, algorithmic or heuristic design propositions, design exemplars and patterns, models or frameworks, and stories or narratives. In our IS design science research we have developed IS design knowledge in different forms, for example, as design propositions and frameworks. How this can be done will be presented in the next section.

15.4.3 Developing IS Design Knowledge

IS design science research based on the above is carried out through an IS design science research "cycle" consisting of four major research activities (Fig. 15.2): (1) identify problem situations and desired outcomes, (2) review (kernel) theories and previous research, (3) propose/refine design theory, and (4) test design theory. The figure reveals that IS design science research is not only about doing or designing. An important part of this research approach is to continuously test design theories. This includes testing of theories' applicability, understandability, and actability in practice. Another key characteristic of my IS design science research approach is that one should build on what is already known, i.e., kernel theories and previous research.
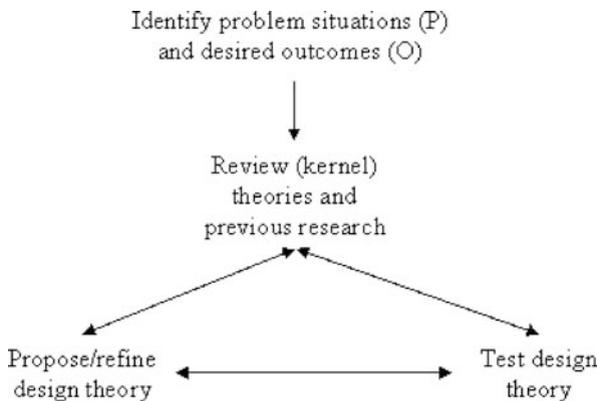

Fig. 15.2 Information systems design science research: development of design theories and design knowledge (based on Carlsson et al. (2008, forthcoming) and Hrastinski et al. (2007, forthcoming))

15.4.3.1 Research Activity: Identify Problem Situations And Desired Outcomes

Design theories and design knowledge aim to support solving practical problems in such a way that desired outcomes are reached. Hence, such theories and knowledge are goal- and outcome-oriented, which means that they should when used increase the likelihood of reaching desired outcomes. Below, three examples of design theories and knowledge and the practical problems that motivated the need for these theories are presented. These design theories and knowledge were developed to guide IS practitioners in how to achieve desired outcomes.

15.4.3.2 Research Activity: Review (Kernel) Theories and Previous Research

Design theories and design knowledge should be enhanced through grounding in previous research. A design theory should be enhanced by continuously "interacting" with what is currently known, that is, grounding in kernel theories and previous research. Gregor (2006) distinguishes five interrelated types of theory: (1) theory for analyzing, (2) theory for explaining, (3) theory for predicting, (4) theory for explaining and predicting, and (5) theory for design and action. Gregor argues that other types of theory can "inform" design theory and that design theory and explanatory and predictive theory are strongly interrelated. van Aken (2005, 2006) maintains that design knowledge in the form of design propositions can be developed through cross-case analyses of previous case studies – see, also, Carlsson et al. (2008, forthcoming), Gregor (2009), and Hrastinski et al. (2007, forthcoming). This means that design knowledge is abstracted from cases. van Aken (2004) refers to this as "extracting case studies" and shows how it has led to a number of useful and actionable design propositions, for example, Kanban Systems and Just-In-Time.

In general, design theories and design knowledge can be enhanced through systematic reviews of previous research. Several scholars (e.g., Pfeffer and Sutton 2006) have argued for the development of evidence-based or evidence-informed management knowledge, including evidence-based design knowledge. In the IS design science research cases presented below, the reviews of previous research were inspired by Pawson's (2006) suggestions on how to conduct systematic reviews to make sense of a heterogeneous body of literature. Such reviews should be driven by PIMCO configurations and should have a specific focus on outcome(s) and how outcome(s) can be produced or enhanced. Using this method for review of relevant literature means that it is possible to move away from the many one-off studies and instead learn from fields such as medicine and policy studies on how to develop evidence-informed IS design knowledge.

15.4.3.3 Research Activity: Propose/Refine Design Theory

When proposing a design theory, for example, in the form of design propositions, it is important to provide "thick descriptions" to aid the reader in understanding the

theory, which may support practitioners in translating a theory to specific contexts and situations (van Aken 2005).

A design proposition follows the logic of a technological rule. In the field of IS it may be more appropriate to use the term design proposition instead of technological rule since the latter term may suggest a technical, rather mechanistic approach (Hrastinski et al. 2007) – technological rules are also discussed in Chapter 14. A design proposition can be expressed as follows: In problem situation (P) and context (C), to achieve outcome (O), then design and implement IS initiative (I) (adapted from Bunge 1967). As presented above, the "design and implement IS initiative I" includes three different types of designs: (1) *object design*, (2) *realization design*, and (3) a *process design*. Since a design proposition should be used by practitioners it should be understandable, applicable, and actionable.

A field-tested and grounded design proposition has been tested empirically and is grounded in science. The latter means primarily grounding in results and theories from the behavioral science paradigm. Field-tested and grounded design propositions will in most cases be in the form of heuristics. This is consistent with critical realism's view on causality (Bhaskar 1978, 1998; Groff 2004) and means that the indeterminate nature of a heuristic design proposition makes it impossible to prove its effects conclusively, but it can be tested in context, which in turn can lead to sufficient supporting evidence (Hedström and Swedberg 1998; Groff 2004).

15.4.3.4   Research Activity: Test Design Theory

After having formulated an initial design theory, the next step is empirical tests, which include the selection of appropriate data collection methods (Carlsson 2006). In doing this, it can be examined whether the design theory may be used as support when trying to "change" reality. Based on the results, the outcome may be reflected on and the design theory may be refined. Through multiple studies one can accumulate supporting evidence iteratively and continuously move toward "evidence saturation." We can say that the tests of a design theory go through alpha, beta, and gamma testing. Alpha testing concerns further development by the originator(s) of the design theory. Beta testing concerns further development by other researchers. Gamma testing concerns testing the design theory in practice and includes testing whether practitioners can use it and if the use of the theory leads to the desired outcome(s). To strengthen the validity of design theories, test triangulation may be beneficial, i.e., to combine two or more complementing ways of conducting gamma testing, such as focus groups and field experiments. Further guidance on how to conduct gamma tests are provided by Rosemann and Vessey (2008), who use the term applicability checks to describe this type of testing. They suggest that applicability checks can be made through focus groups, which we have used with appealing results (presented below) – see, also Chapter 10. However, it should be recognized that it can be practically unfeasible to, as suggested by Rosemann and Vessey (2008), gather IS managers to conduct an evaluation. For the future I see a need for a discussion on different techniques for testing design theory and design knowledge and their applicability.

15.4.4 Examples of How to Develop IS Design Theories and Design Knowledge

This section illustrates how my colleagues and I have used the proposed approach when developing three design theories. For each theory, I will briefly describe each of the four research activities. I do so partly not only to illustrate how the approach can be used but also to show that studies based on the approach have been peer reviewed and accepted for publication by the IS community (for more detailed discussion of the design theories, – see Carlsson and Kalling (2006, 2007), Carlsson et al. (forthcoming) and Hrastinski et al. (2007, forthcoming)). Since the studies were done with colleagues I will use "we" instead of "I."

15.4.5 Design Theory #1: Developing a Design Theory for Turning KMS Use into Profit

15.4.5.1 Identify Problems and Desired Outcomes

An underlying assumption of knowledge management (KM), including knowledge management systems (KMS), is that a firm's competitive advantage to a large extent flows from its unique knowledge and how it manages knowledge. Unfortunately, little empirical evidence exists to show that this assumption is true. Even less knowledge on how to manage KMS initiatives to increase financial performance exists (Edwards et al. 2003). This project aims at producing theoretically and empirically grounded KMS design knowledge. The KM/KMS literature is clear on that failures are unacceptably high. The literature suggests also that the field of dreams approach – "if you build it, they will come" – usually fails. The primary cause is the failure to adequately predict and manage the organizational impacts of KM/KMS investments. The project aims at developing a KMS design theory for how to manage KMS investments. Specifically, we focus on how to manage adoption and exploitation of KMS.

A general goal when designing and implementing a KM/KMS initiative is that it should lead to improved performance. The construct "improved performance" forces attention to the dependent variable(s). This research focuses on organizational "net benefits" in terms of financial performance.

15.4.5.2 Review (Kernel) Theories and Previous Research

The review of previous research was inspired by the work of Pawson (2006) and driven by a focus on outcome (profit improvement through KMS use) and how the outcome can be "produced." We tried to identify how KMS management had been used for turning KMS use into profit improvement. The literature on this was very sparse, which meant that we focused not only on success factors and processes but

also on failure factors and processes. Underlying kernel theories included primarily knowledge sharing theories, for example, the work of leading KM researchers like Nonaka, Takeuchi, von Krogh, Davenport, Prusak, and Patriotta.

15.4.5.3 Propose/Refine Design Theory

In the multiple case studies conducted for generating the design theory we addressed the research question: Why and how is it that a knowledge sharing initiative works? The design propositions were generated based on a cross-case study (Carlsson and Kalling 2006, 2007). The design propositions were also theoretically grounded, primarily in knowledge sharing theories. The multiple case study was of a KMS initiative in a large multinational firm. The purpose of the KMS initiative was to, through the use of a KMS for knowledge sharing, support production improvement decision making. A KMS, with high information (knowledge) and system quality, to be used for knowledge sharing had been developed and implemented in the firm's plants. Thirty-eight plants were similar enough to be used for a comparative study. A quantitative study of the 38 plants was done. The study addressed (1) whether knowledge sharing had occurred, (2) the effects of sharing on cost items and price, and (3) the effects on profit. After having studied the general links between sharing success and financial performance, certain patterns became evident. In order to study them further, six plants with different degrees of success were singled out for onsite case studies. In this qualitative study we identify a process consisting of three phases: (1) knowledge sharing through the use of the KMS, (2) managing the conversion of knowledge, and (3) improving profit margins. We also identify eight critical success factors and linked them to the different phases. Based on the cross-case study our tentative design theory was generated in the form of nine design propositions for turning KMS use into profit. Examples of design propositions are as follows:

- Design Proposition #2: If you want the sharing initiative to have a positive impact on operations, then link knowledge use to operational decision making and action taking.
- Design Proposition #9: If you want an initiative to have a positive effect on financial performance, then establish, institutionalize, and measure (interlinked) three types of outcomes: employee behaviors, process changes, and financial results.

15.4.5.4 Test Design Theory

One important activity in design theory development is tests. As said above, three types of tests should be performed: alpha, beta, and gamma tests. In this case alpha test has been conducted through applying the generated design propositions on a

few numbers of cases. The design propositions have been quite informally tested by practitioners (gamma test). This test has been in the form of presenting the design propositions and having practitioners evaluate the following: (1) Are the design propositions understandable? (2) Are the design propositions actionable? and (3) Is it likely that using the design propositions will result in desired outcomes? Drawing on the test results, the design theory is currently refined. Further testing of the design theory is needed.

15.4.6 Design Theory #2: Developing a Design Theory for Successful Use of e-Learning

15.4.6.1 Identify Problems and Desired Outcomes

In order to succeed with e-learning initiatives, organizations and educational institutions must understand benefits and limitations of different e-learning techniques and methods. An important task for research is to support practitioners by studying the impact of different factors on e-learning effectiveness. Commonly, two basic types of e-learning are compared, i.e., asynchronous and synchronous e-learning. Up till now, e-learning initiatives have mainly relied on asynchronous means for teaching and learning (Hrastinski and Keller 2007). However, recent improvements in technology and increasing bandwidth have led to an increasing popularity of synchronous e-learning. Many practitioners are interested in using e-learning but simply do not know what the benefits and limitations of different approaches are (Hrastinski 2007, forthcoming) and which effects these approaches have on learning outcomes (Cole 2000). However, e-learning use also has organizational implications. Acceptance, i.e., the willingness of teachers and students to use e-learning environments, is a prerequisite for participation (Keller 2007). Thus, this design theory is intended to contribute toward a deeper understanding on a topic where guidance is urgently needed.

15.4.6.2 Review (Kernel) Theories and Previous Research

The review was driven by a focus on outcome, in our case participation, and how outcome can be "produced" (in our case when synchronous and asynchronous communication can be used to enhance participation and learning outcomes in e-learning settings). Underlying kernel theories included technology acceptance models (Venkatesh et al. 2003) and social learning theories that view participation as critical to the learning process (e.g., Vygotsky 1978; Wenger 1998). The cognitive model of media choice (Robert and Dennis 2005) served as an aid in explaining when synchronous or asynchronous communication may be preferred. Furthermore, to focus on the quality of learning outcomes in online education, learning theories describing the prerequisites of deep learning, as opposed to surface

learning (e.g., Bloom 1956; Marton et al. 1977), were included among the kernel theories.

15.4.6.3 Propose/Refine Design Theory

In our previous research, the research question of which factors contribute to successful use of e-learning was explored. As a foundation of our design theory, we proposed that acceptance of e-learning environments is a prerequisite for participation in e-learning settings. Participation is, in its turn, a prerequisite of high-quality learning outcomes. The research question was addressed by developing eight design propositions, intended to guide practitioners on the use of e-learning. However, this research activity was revisited many times: The design theory was continuously improved, as lessons were learnt by testing the theory and by analyzing previous research. Examples of design propositions are as follows:

- Design Proposition #5: If you want to enhance "cognitive" participation to provide deep learning, then support asynchronous communication.
- Design Proposition #7: If you want to enhance weak class-wide relations among students, then support "formal" communication.

15.4.6.4 Test Design Theory

One important aspect of design theory development is the empirical test. When having proposed an initial design theory, an empirical gamma test, i.e., a test with practitioner involvement, was conducted. Krueger (1994) argues that focus groups are an appropriate method for evaluating the effect of interventions in social contexts and, thus, seem appropriate for evaluating design propositions by obtaining feedback from experienced practitioners. A brief version of the design propositions was published in a Swedish e-learning magazine. In the article, teachers, managers, administrators, and developers with experience of asynchronous and synchronous e-learning were invited to participate in focus groups to evaluate the design propositions of the theory. Drawing on the results, the design theory was refined.

15.4.7 Design Theory #3: Developing a Design Theory on How to Improve the Capability of IS Integration in M&As

15.4.7.1 Identify Problems and Desired Outcomes

M&As now become a major tool for corporate strategy and an integrated part of many global firm's growth strategy. In a survey by Accenture of 400 corporate executives in the USA and Europe only about 1/3 regarded their last IS integration in a cross-border M&A a "success" (Accenture 2006). IS integration is the

third most cited reason for M&As not being able to deliver its expected financial improvements (Rodgers 2005). Yet so, only 16% of companies involve IS management in pre-M&A phases (Accenture 2002).

We asked why firms were adopting this behavior and found that there is simply no management guidance or support building on science and theory available. Thus, our purpose was to develop theoretically grounded knowledge that would assist IS professional dealing with IS integration in M&A. As one part of this outset we addressed the task of improving IS integration from one M&A to the next, which is the design theory presented here.

15.4.7.2 Review (Kernel) Theories and Previous Research

The review was driven by a focus on outcome, in this case improvement of management of IS integration in M&A. The review covered fields like IS (and IT) management, governance and alignment, as well as M&A theory, and the field of organizational learning.

15.4.7.3 Propose/Refine Design Theory

The existing theory explaining how organizations learn, or fail to learn, from one M&A to the next suggested four relationships between organizational learning and IS integration in M&A. These relationships could be restated as design propositions and along with our recommended "thick descriptions" presented to the IS community as an initial design theory. Examples of design propositions are as follows:

- Design Proposition #3: If no reason exists for a heterogeneous IS base, standardization in systems and processes is desirable.
- Design Proposition #4: If the company frequently engages in M&As and needs to develop a strong IS integration capability, using internal IS professionals and not consultants can enhance that capability.

15.4.7.4 Test Design Theory

Testing of the design propositions was made with beta and gamma testing. In the beta testing four researchers with experience from IS in M&A evaluated the propositions for importance, accessibility, and suitability. The gamma testing was made based on the same criteria. Two distinct group of potential users were selected, one with senior IS managers with experience of IS integration in M&A and one of younger IS professionals that had no experience of M&As. In this case it was considered practically unfeasible to collect all high-level IS managers in one place at the same time to participate in focus groups. Instead individual sessions were held which ended out in completed survey forms.

15.5 Conclusion

In this chapter I have presented an IS design science approach. The approach is a complement to the two influential schools. The underpinning philosophy of the approach is critical realism – as noted by Indulska and Recker (2008) there is a lack of approaches having clear ontological and epistemological views. The approach can be seen as part of the changing view on IS design science research noted by Kuechler and Vaishnavi (2008). They say that the "...view of IS design science research as a 'hard' engineering practice is being mitigated in the USA by the increasing influence of European concepts of IS and design in IS; these have traditionally incorporated a greater emphasis on the business environment."

Further theoretical and empirical work is required to enhance and test the approach. Currently, my colleagues and I are using the framework in a number of IS design science research studies. My suggestions make no claims to be the final word in the debate on IS design science research, but research based on the framework could lead to a stream of research that *meets the criteria of scholarly quality*, *addresses practical (professional) issues and problems*, and *generates practical design knowledge*.

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