The Fusion of Design Science and Social Science Research

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Abstract

The importance of including the study of both artefactual and naturally occurring phenomena in scientific endeavours is apparent. Prior work has shown the significance of the knowledge flows from pure to applied sciences and vice versa. Further, a summative notion of a composite reality, partly artificial and partly natural, means that in many circumstances today, artificial sciences, natural sciences and social sciences are incomplete without each other. Yet in Information Systems some perceive a gap between research activities of the social science type and of the design science type. This essay proposes a fusion model of linked social science and design science research activities that allows connections among research activities to be examined. The model depicts five linked phases of research activity: (1) artefact construction; (2) prescriptive theorizing; (3) study of artefacts in use; (4) tests of knowledge with artefacts in use; and (5) descriptive theorizing. Examples show how the research cycle can be entered at any point and how phases are linked. The model gives an improved understanding of the interdependency of social science and design science research and points to ways in which communications amongst researchers can be improved, thus providing an avenue for the advancement of the discipline of Information Systems.

1. Introduction

Artefacts[1] comprise a large part of the physical and social world in which we live. Our physical world is dominated by artefacts such as buildings, vehicles, electricity and cooked foods. Our social world is shaped by laws, conventions, media, procedures and records. Humans have lived with artefacts for millennia; in fact, it is debatable whether humans have ever existed without artefacts. The ubiquity of the artefact drove Simon to wonder why descriptive sciences, such as natural science or behavioural science, had grown to dominate scientific thinking in the absence of prescriptive sciences or "sciences of the artificial" (Simon, 1996).

Simon's proposition seems compelling. Alongside the prized scientific work that ***de***scribes our world, such as biology, chemistry, and physics, Simon urged us to elevate the equally prized scientific work that ***pre***scribes our world, such as architecture, engineering, and medicine. Simon recognized that, once created, artefacts adhered to the laws of descriptive science. He also acknowledged that, as the result of our technologies, much descriptive work focuses on describing the behaviour of a world that is part natural and part artefactual. In sociology, for example, it is nearly impossible to study human behaviour without placing it in a context where physical and social artefacts exist. Similarly, it is nearly impossible to study physical or social artefacts in the absence of related human behaviour. Every artefact has, at least, a humanly-defined goal as its objective.

Simon's proposed ascent of the sciences of the artificial inhabits questions raised in information systems design science research[2]. For example, is a design scientist at a disadvantage in relation to a behavioural social scientist in the university reward system (Junglas et al., 2011)? Does design science respond to different criteria than behavioural social science (Osterle et al., 2011)? Are design science research results suppressed in information systems journals (Baskerville et al., 2011)?. Is there an inherent lack of theory in design-science research (Sinha et al., 2011)? How large is the design science-behavioural research divide (Sinha et al., 2011)?

Such questions not only imply that design science lacks legitimacy or value; these questions assume that the design sciences and behavioural social sciences are (or ought to be) separable. This assumption echoes the long standing distinction between pure science and technological science activities and between the types of knowledge produced in these activities (Mokyr, 2002; Stokes, 1997). In relation to innovation and economic growth, the economic historian Mokyr (2002) argued that growth is enhanced when there is communication and trust between those engaged in developing descriptive (pure science) knowledge and those producing prescriptive (technological) knowledge. The industrial revolution of the 19th century was made possible not only by the scientific discoveries of the previous century but also by the increased accessibility of descriptive knowledge to innovators and inventors through scientific societies, new journals, encyclopaedias and improved communication. Mokyr argues that knowledge growth as a whole is inhibited by factors that hamper communication and knowledge flows between researchers in technological research and those in pure science.

[1] We use the term artefact in its primary English sense: "An object made or modified by human workmanship, as opposed to one formed by natural processes." OED, Third edition, September 2008; online version June 2012. <http://www.oed.com/view/Entry/11133>; accessed 03 July 2012. An entry for this word was first included in A Supplement to the New English Dictionary, 1933.

[2] Design science research (DSR) is defined as "a research paradigm in which a designer answers questions relevant to human problems via the creation of innovative artifacts, thereby contributing new knowledge to the body of scientific evidence. The designed artefacts are both useful and fundamental in understanding the problem" (Hevner and Chatterjee 2010 p. 5).

Innovation and scientific advances in information technology (IT) related fields can add greatly to economic progress and human well-being. But the knowledge growth in this area should increase if the researchers engaged in work at the prescriptive, design science end of the spectrum and researchers engaged in work at the descriptive, social science end of the spectrum better understand their own interdependence and needs for communication.

The aim of the paper is to challenge the assumptions of a gap between DSR and social science research (SSR) in IT disciplines, including information systems, and to provide a model that shows how a fusion of these modes of work can occur in cycles of research activity. Our argument is that the fusion model linking DSR and SSR contributes to an understanding of how to achieve significant knowledge advances that have impact for research and practice. We illustrate this argument with examples of research projects and programs that demonstrate aspects of the fusion model.

The essay proceeds by first examining the relationships perceived between pure and applied science historically and the concept of a summative notion of a composite reality, partly artificial and partly natural, that should be recognized in research activity. The fusion model is proposed and illustrated with research examples from the extant literature and the essay concludes with implications of improved understanding of the interdependency of SSR and DSR.

2. Background

2.1. Pure and Applied Science Historically

Distinctions between pure and applied branches of science have been made at least since the differentiation of *epistêmê* from *technê* by Aristotle. Authors have continued to address the interactions between these fields in terms both of research activities and knowledge flows.

For example, Stokes (1997) considered the relationship between pure (basic) science and technological innovation and pointed to what he termed ‘Pasteur’s Quadrant”, a desirable state of affairs where the aim of general understanding from basic science coalesces with the aim of usefulness of applied research. Work in this quadrant is “use-inspired basic research” (p. 73) that seeks to extend the boundaries of knowledge as well being motivated by considerations of use. The exemplar for research of this type is provided by Louis Pasteur, who in one project began by investigating a problem set for him by industrialists trying to make alcohol from beets. Pasteur’s investigation of the problem gave an answer to the industrialists but also led to valuable discoveries in terms of the behaviour of the microorganisms responsible for fermentation. Stokes gives many other examples which show the flow of innovation and knowledge development as being from use or problem inspired research to pure research, rather than the other way round. In doing so, he challenges commonly-held views, including those of Vannevar Bush, who influenced policy on science funding in the US in the mid-twentieth century and beyond (Bush, 1990). Bush saw a tension between pure and applied research and thought that they should not be mixed and that considerations of practical use were actually inimical to the creativity of basic science. This linear view of science, with work in pure research leading eventually to applications in technology, has been adopted elsewhere. In Australia, for example, the 1957 report from the Murray Committee that advised the Australian government on university policy expressed a view that basic and applied research were separate activities, pursued by different types of people with different talents and different interests and that pure research came first, with applications derived from it coming later, often much later (C.A., 1957). Similar views remain pervasive, but the view argued in this essay follows Stokes in seeing the intertwining of pure and applied research as a more realistic depiction of knowledge advances.

Further support for the idea that pure and applied science should be viewed as intertwined is provided by, amongst others, the economic historian Mokyr (2002). Mokyr distinguishes between the propositional (descriptive) knowledge arising from basic research into natural phenomena and the prescriptive or technical knowledge that informs action. Mokyr argues that progress in exploiting knowledge depends on the cost and efficiency of access to knowledge of both types. Further, the two types of knowledge are related: the prescriptive knowledge for technologies rests on knowledge of regularities of natural phenomena and the descriptive knowledge includes knowledge of how technologies behave. Mokyr sees a forward flow loop from prescriptive to descriptive knowledge, with the descriptive knowledge base enhanced with facts about how techniques work, research opportunities from new technologies in the form of instruments and with technological success providing support for new propositional knowledge. New propositional knowledge then informs subsequent prescriptive knowledge building. The idea of these feedforward and feedback loops is built upon in the fusion model presented in this essay.

First, however, we look at the relationship between pure and applied research in more detail in terms of our understanding of the Sciences of the Artificial, identified by Herbert Simon as the branch of science to which fields such as information technology, information systems and economics belong (Simon 1996).

2.2. Position of the Sciences of the Artificial

Artificial (design) sciences do have some fundamental differences compared with the natural and social sciences. "Whereas natural science tries to understand reality, [an artificial] science attempts to create things that serve human purposes." (March & Smith, 1995, p. 253) This distinction is not trivial because artificial sciences are engaged in creating, not just understanding, reality. The design sciences must focus on the ontological consequences of designed artefacts in physical and social reality. The newly created reality is changed by the addition of artefacts, meaning it becomes a summative reality, one consisting of both the natural world (e.g., granite, crocodiles, sunshine, gravity), and the artificial world (e.g., buildings, zoos, neon lights, jets). Ontologically, reality is a composite of the natural and the artificial. Both the natural and the artificial elements remain subject to natural laws and social behaviours, and both can be studied from natural or artificial science perspectives (Simon, 1996).

This summative notion of a composite reality, partly artificial and partly natural, means that, in many circumstances today, artificial science, natural science, and social science are incomplete without each other. The artificial sciences engage in creating parts of the reality that is the subject of the natural and social sciences. One outcome of this potential dependency on the creation and study of summative realities is the unavoidable fusion between artificial science, natural science, and/or social science research, particularly in design science settings.

From a social science perspective, this fusion is inhabited by the potential for the social reflection of the designer's behaviour. Because the designer is a person with social and cultural features, the designer's design choices are influenced by these features. Subsequently behaviour of people engaged in the reality shaped by this designer can be influenced by these choices. For example, should museum patrons exit through the museum shop, the museum café, or directly into the lobby? This choice influences whether patrons might take a part of the museum home, linger over their museum experiences, or head for the bus. By design, the physical and social reality is often prefabricated to some extent prior to study. The summative result is that the natural and social sciences quite often study the reflections of past designer behaviour without necessarily recognizing it as such.

In an artificial science, assumptions about a gap between design science research and social science research overlooks the tight, summative coupling between design behaviour and the subsequent behaviour that results from the addition of newly created artefacts to social (and possibly physical) reality. Because of the summative nature of designed and natural reality, the two research realms interact inescapably. The nature of the gap is not embodied by the lack of interaction or coupling, but rather by the flow of knowledge between the design and social realms of research. In design science research, this flow of knowledge has been represented in different ways, for example as a three cycle model in which a build-and-evaluate cycle mediates how social knowledge is both applied in a relevance cycle and extended in a rigor cycle (Hevner, 2007). From a purely scientific viewpoint, the knowledge flows recognize artefact creation as a mediator in the process by which we expand our knowledge. An alternative model might see a more direct flow from descriptive to prescriptive modes of theorizing and validating, as represented in the ideas of Vannevar Bush in the US, with the results of basic research leading on to practical applied research and development. Or, as Stokes (1997) argues, the flow is often from practical problem inspired research to basic research, as with the work of Pasteur.

Our understanding of the knowledge production process operates at two levels of abstraction. On the one hand, we can regard the process of science as a humanity-wide movement, a macro view of the production of knowledge (Fischer, 2011). From the summative view of reality, the macro view acknowledges the progress of science from artificial (that elaborates reality), thereby enabling natural and social sciences (in our setting, especially social) to extend our knowledge about reality as a result of this elaboration. We might represent this as a left-to-right progression, as in Figure 1.

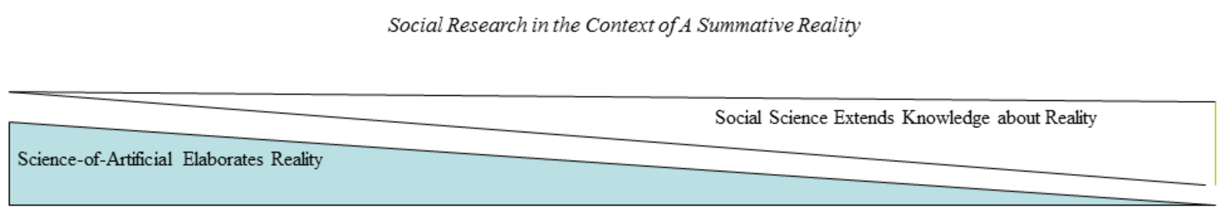

Figure 1: Social Research in the Context of a Summative Reality

Were progress linear at the macro level, such a linear representation might suffice. However, the sciences of the artificial interact with the other sciences because new artefacts are often composed of other, pre-existing physical and social elements (natural or artificial), so the process is at least cyclical in nature, perhaps better represented as a yin-yang interplay (see Figure 2).

But the branches of science can also interact at a micro level of abstraction, which might be described as the overlap between the sciences of the artificial (in our case, design science) and the other sciences (social science in the information systems case) in the engagement in research activities. While the discussion of the relationships between the natural, social and artificial sciences is useful in providing an orientation to research at a macro level, we argue that the interrelationships among the sciences is such that inevitably difficulties arise in deciding what should be labelled “natural” as opposed to “social” or “artificial” science. We find it more useful in this essay to distinguish “research activity” at the micro level in terms of the paradigm in which the research type has its primary roots, rather than distinguishing between the branches of science as monolithic separate pillars. Thus, in the remainder of this essay, we use the terms "social science research" (or "social science research activity" or "social science research phase" synonymously) to refer to behavioural research activities that are commonly described in standard texts on social science research. For example, Neuman (2010) describes social science research as including surveys, experiments, archival work, and case studies. On the other hand, the term "design science research" ("design science research activity", "design science research phase" synonymously), is used to refer to research activities that are commonly described in standard texts on design science research. For example, Hevner and Chatterjee (2010) describe design science research as including building and evaluating with methods including performance analysis, surveys of users and field studies. Even from this description we can see some overlap between the activities included under each label. However, the overlap (or lack of it) has been little analysed previously in any systematic way. It is to address this problem that the current "fusion" model is proposed.

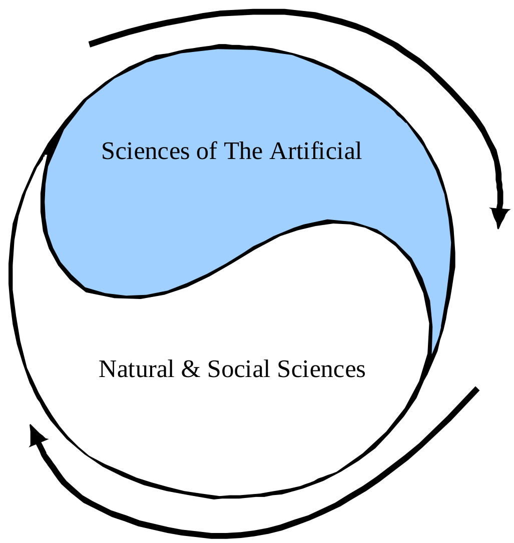

Figure 2: Interplay of Natural, Social and Artificial Sciences

3. Fusion Model for Integration of DSR and SSR Activities

Figure 3 shows the fusion model that is proposed for DSR and SSR in a Science of the Artificial that involves human and social usage of artefacts. At the micro level, say in a particular research project or research on a particular theme, we can recognize circular processes that commence with work in the design science paradigm, producing novel artefacts that immediately open opportunities for studying the social aspects of the revised reality. While such social studies might be couched in terms of evaluation from the perspective of design science, such studies potentially offer new knowledge about the revised social reality that results from the insertion of new artefacts in that reality.

Because our context is information systems, social science will most often dominate the extension of knowledge toward the right of the diagram. In other cases, where humans do not directly use the artefacts, we could substitute physical sciences, simulations and mathematical proofs. We would nevertheless retain the prevalent fusion between the prescriptive and descriptive aspects of the model.

An important aspect of the fusion model is that the research cycle in the model can be entered at many points – research projects could begin at the construction phase, or in the design theorising phase, or with observational studies of artefacts in use, or in general theorizing about artefacts in use. A second important aspect of the model is the need for feedback from one phase to another in the loop. There is a strong argument for the "fusion" element of the model: that is, that there must be knowledge flows from SSR phase back to DSR phases (based on Moykr's arguments) (Mokyr, 2002). If these flows are not happening then research is not as fruitful as it could be for innovation and overall knowledge development.

These aspects of the model are examined further in later discussion.

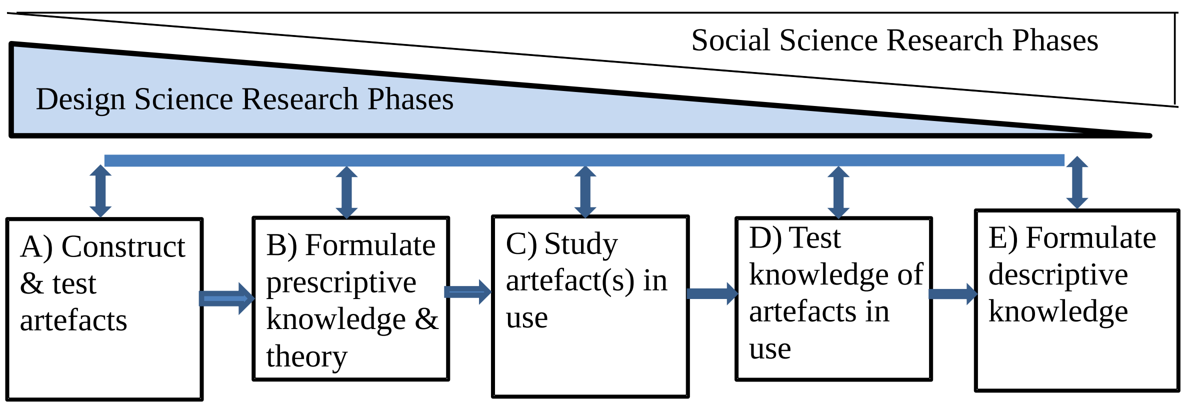

Figure 3: The Fusion Model for Design and Social Science Research
(arcs show knowledge flows)

The reasoning behind the fusion model follows. Note that the phases might not occur exactly in this sequence – there may be jumps from one phase to one further along in the cycle. There will also be variations in the nature of the activities in each phase.

The DSR research phases are primarily A, B and C, while the SSR phases are primarily C, D and E. The phases are as follows:

- *Phase A – Artefact construction.* This phase includes the research activities typically depicted for DSR. For example, Peffers et al. 2008 describe the activities in DSR as including: (1) problem identification; (2) definition of objectives; (3) design and development; (4) demonstration; (5) evaluation; (6) communicate results.

- *Phase B - Prescriptive theorizing*. This phase in part overlaps with Phase A, which includes communication of results. However, it is depicted as a separate phase to emphasize the importance of formalizing generalizable design knowledge, either from one's own development efforts, or from that of others. It is possible for researchers to enter the cycle at this point to develop generalized design knowledge and theory, either on the basis of constructed artefacts, or even possibly for yet-to-be artefacts.

- *Phase C – Study of artefacts in use*. In this phase the artefacts are in use outside the research environment where they were developed and their effects on other parts of the world can be observed. Hypotheses may be formed about interactions between the artefacts and other phenomenon.

- *Phase D – Tests of knowledge with artefacts in use*. Observations or hypotheses about the artefact in use are subjected to validation or testing. Phases C and D correspond to the context of discovery and the context of justification respectively in an idealized form of the scientific method (see Fischer and Gregor 2011).

- *Phase E – Descriptive theorizing*. In this phase the knowledge that has been accumulated, possibly in several different research projects in different phases, is integrated into theory. The theorizing activities occur as part of other phases, but again are shown as a separate phase to emphasize their importance.

Note that the DSR and SSR phases are shown as overlapping. On occasions, SSR extends to phases A and B, with SSR including development of a representative artefact as an experimental vehicle for use in experiments. Some of this type of work, although basically behavioural/social science research, will develop design principles (prescriptive knowledge). In a classification of DSR work, Fischer (2011) refers to this type of work as “micro” DSR as opposed to macro-DSR in which a full-blown artefact is developed. Alternative terminology could be “weak” as opposed to “strong” DSR.

The table in the Appendix provides an example of the research activities that could occur in the fusion model (column 2). As a comparison an example is also given (column 1) of activities that would occur in “pure” social science research where no artefact is constructed, and no implications for artefact construction are drawn. The purpose in providing this example is to show in more detail the activities in the fusion model.

A particularly interesting aspect of the fusion model is the feedback loop from the descriptive knowledge developed in phase E to the construction of further artefacts in phase A, and a number of authors have begun to address this issue. Gregor (2009) made a distinction between the “interior mode” of design science theorizing compared with the “exterior mode” of natural science theorizing. She sees these two modes of theorizing as “two sides of a coin”. A proposition in the exterior mode such as “’Design feature A leads to better performance than design feature B on criteria X”, if given empirical support, can be turned around to give a design principle “Consider A rather than B if you want better performance on X”. Gregor stressed, however, that prescriptive design principles cannot be deduced in any strictly logical manner from prescriptive statements – they may provide a guide but there are usually still many alternatives for action. The design principle is “consider A rather than B”, not, “you must use A”, as other alternatives C, D, E … may be better than both A and B.

Recently, Kuechler and Vaishnavi (2012) advanced the idea of design-relevant explanatory-predictive theory (DREPT). DREPT is mid-range theory that is congruent with kernel theory (general explanatory theory), but is couched in terms such that it can be relatively easily transformed into prescriptive design principles. The constructs in the high level non-design domain are translated into constructs relevant to the technology/information systems domain. These authors demonstrate with a number of examples how DREPT provides guidance for future designs, giving good examples of the feedback loop from descriptive to prescriptive knowledge.

4. Illustrations

Some examples are provided of research that is classified into one of the five phases of the fusion model. These examples show how the cycle in the model can be entered at any phase. They also show how knowledge flows from one phase to another.

4.1. Phase A – Artefact Construction

This phase is the typical DSR phase and there are many examples of research activity that fit in this phase. To choose just one example, McLaren et al. (2011) developed and tested a seven-step multilevel measurement model for assessing strategic fit in organizations. They built on prior descriptive knowledge, such as work on relationships between strategic types, marketing competencies and organizational performance, thus demonstrating a link between Phase E and Phase A activities. McLaren et al. also formalized their prescriptive knowledge in the form of a nascent design theory (as in Gregor and Jones 2007), thus showing an overlap between Phase A and Phase B activities.

4.2. Phase B - Prescriptive Theorizing

Some authors, including McLaren at el (2011), continue their work in Phase A into Phase B to formulate the results of their design as a design theory,

In contrast, some researchers begin at the prescriptive theorizing phase, although this entry point is relatively unusual. Moody (2009) shows how the fusion model cycle can be entered at this phase, with the development of a design theory without first developing an artefact. Moody developed principles for the design of cognitively effective visual notations, building on theory from cognitive science and other sources, thus demonstrating a link between Phase E directly into Phase B. Moody termed his design theory, the "Physics of Notations" and this theory has now been used in further work to evaluate existing notations (Moody et al., 2011), showing a link between Phases B, C and D.

4.3. Phase C - Study of Artefacts in Use

In this phase artefacts that result from Phases A and B have been put into use in the everyday world and are studied in this context. Researchers can adopt social science methods and treat the artefact as part of the observable world along with naturally existing phenomena. The observations of the artefact in use can be used in theory building. Hypotheses may be generated to predict the behaviour that will accompany the use of artefacts. An example with socio-technical artefacts is provided by Gable (1994), with reference to case studies of the facilitation of IT adoption and consultant engagement that led to a research model that could be tested in subsequent survey research (Phase D).

This phase is important because it provides empirical grounding for theory building. Anomalies may be discovered that were not expected from either design theorizing or prior higher-level reference theory. For example, Wognum (1990) studied the use of explanation facilities of various types in operational knowledge-based systems in the Netherlands. She found that users had demanded the inclusion of a certain of explanation (a "which?" function) that had not been included by designers. This function had been little, if at all, studied at the time in either research design work (Phases A and B) or experiments in social science type work (Phases D and E).

4.4. Phase D – Tests of Knowledge with Artefacts in Use

In this phase artefacts are studied in use in real-world or experimental settings, but here the purpose is to validate or test the knowledge and theory that was gained in phase C. Obviously Phases C and D are likely to be tightly linked as they correspond to commonly understood notions of theory building and theory testing. Phase D can include studies that develop and test research models with relationships amongst theoretical constructs, including at least some constructs that relate to information systems/IT artefacts. These models may have resulted from grounded-type activities in Phase C, or may be drawn from higher-level descriptive theory (natural or human sciences) that is expected to be relevant to the use of the artefacts. There are numerous examples of the latter type of work.

One example is the study by Xu, Benbasat and Cenfetelli (2011), who developed a model of online customer loyalty from Unified Services Theory and Social Exchange Theory and then tested the research model in an experiment with real-life web sites.

4.5. Phase E - Formulate Descriptive Knowledge

Research activities in Phases C, D and E in combination lead to formulation of descriptive knowledge and theory. This knowledge may be explicitly integrated and formed into a more cohesive body of theory in activities in Phase E, or may evolve in a cumulative fashion from Phases C and D. The descriptive theory emanating from Phase E should, ideally, feed back into the other phases A to D. It is this type of theory that Kuechler and Vashnaivi (2012) refer to as design relevant explanatory predictive theory.

An example is provided by Gregor and Benbasat's (1999) review of empirical and theoretical work relating to explanations from knowledge-based system. This review developed theory that showed how explanatory capabilities, a feature of knowledge-based systems, relate to human use and behaviour. Propositions were developed such as: explanations that require less cognitive effort (e.g., automatic explanations) will be used more and be more effective. This knowledge is design relevant as it can be readily converted to design principles.

Note that in this review the constructs that were used in the theory included constructs that were used by designers of these systems in Phase A, such as ”automatic explanations”. The empirical work reviewed included many experiments, one field study and one set of case studies of real-life operational systems (the Wognum study previously mentioned). This work shows evidence of knowledge flows through Phases A, B, C and D to E. Citations to the review article show it being used in diverse design work, such as the development of decision support in nuclear remediation management (Geldermann et a;. 2009). Thus, there is evidence of knowledge flow from Phase E back to Phase A.

4.6. Weak and Strong Links in the Fusion Model

The potential for weaker and stronger links in the chain of knowledge flows between phases in the fusion model is of interest.

Our argument is that research in a science of the artificial, such as information systems, is improved when there are strong knowledge flows between the various research activities that occur in design science and social science research. The search for illustrations for activities in each of the phases in the fusion model indicates some possible weak links.

One weak link is indicated between Phases B and C. Relatively few studies were identified that grounded descriptive theory or research models in the study of artefacts in use. None were easily identifiable that referred to the designer's aims for the artefact or design theory from Phases A and B. This situation seems very odd. It is akin to a situation where public policy makers developed a policy (a designed artefact) but then no one conducted empirical studies to examine whether the policy worked after it was implemented or in the way the designers' envisaged. The situation in information systems appears to be that the theoretical models are developed more from reference theory in other disciplines, without grounding in the observation of systems in use.

There is some indication that strong research programs that are successful in terms of both high-quality publications and in research that is valued externally match the fusion model to some degree in having links between constructive design work and social science type studies of artefacts in use. Examples include the research programs at the MIT Sloan School of Management Centre for Information Systems Research[3], Queensland University of Technology[4], University of Arizona[5] and Westfälische Wilhelms-Universität Münster - European Research Centre for Information Systems[6].

5. Discussion and Conclusions

The fusion model of design and social science research explains why there are problematic assumptions that a gap separates DSR and SSR. These assumptions arise from isolating extreme forms of DSR (such as *just* conducting phase A in Figure 3, constructing and testing of artefacts) or extreme forms of SSR (such as *just* conducting phase E in Figure 3, formulating descriptive knowledge).

Isolating "pure" information systems DSR with phase A only, constructing and testing of artefacts, generates certain problems. Such work is open to challenges to justify claims that the work qualifies as science without drawing on formulated descriptive knowledge (kernel theories – phase E) or acknowledging assumptions about formulated prescriptive knowledge (design theories – phase B). When such work concludes with the construction of operational artefacts that meet elementary "bench testing", it can be unclear whether the artefact will prove of value outside of its "development laboratory". Its contribution to knowledge remains at a highly technical level, because its assumptions, grounds and more comprehensive usefulness remain in a speculative, propositional state at best.

At the opposite extreme, isolating "pure" information systems SSR, with phase E only, formulating descriptive knowledge, generates different problems. Such work is open to challenges that the artefacts involved in the study become reified without a full understanding of the artefact's goals and conditions of use. Such work would commence with assumptions that the information artefact is more-or-less similar to natural objects, an immutable natural creation. It can overlook situations in which the use of the artefact in context is different from that intended, and that matches or mismatches between artefact features and its use *in situ* do not allow definitive conclusions about information artefacts or their settings. In idiographic studies, such as case studies, the results provide a contribution to knowledge that is highly situated

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[3] http://cisr.mit.edu/

[4] http://www.qut.edu.au/research/our-research/research-areas/information-systems

[5] http://borders.arizona.edu/cms/about-borders#Mission#Mission

[6] http://www.ercis.de/research

because its assumptions and grounds includes immutability of context and artefact; the applicability of these results to different configurations of artefact or context remain in a speculative, propositional state at best. In nomothetic studies, such as surveys, the groundwork often reduces artefact features and social context to simplified representations not contemporaneous with the artefact's past or future mutations. Such results provide a contribution to knowledge that can be both highly abstracted and limited in duration.

We doubt that such extremes in pure form exist 'in the wild' of information systems. It would be most unusual to construct an artefact that is not linked to design goals grounded in information about the physical or social world of the intended context. Indeed, few DSR projects, (if the "S" indeed means "science") will commence in the absence of theoretical grounding or kernel theories, whether explicit or implicit. As such, DSR phases originate in communication with their SSR past and their intended SSR future.

It is important to recognize that the communications between prescriptive DSR and its more descriptive partners may take place through the constructed artefact itself. When we acknowledge that the variety of artefacts includes, for example, methods and models (March & Smith, 1995), we see that few information systems studies occur in the absence of artefacts (Orlikowski & Iacono, 2001). Among their features, artefacts are information bearing because their features, behaviour, and environmental interfaces help convey the intended meaning of the artefact (Committee on Academic Careers for Experimental Computer Scientists, 1994; Simon, 1996). Once we understand that artefacts also enact a role of communication media, we begin to recognize that descriptive studies undertaken in the (nearly necessary) presence of artefacts are implicitly open to the influence of indirect communication with the artefacts' designers.

The interdependence of DSR and SSR prevents the possibility of severe gaps because communications are already flowing across the extremes in the model. If a gap exists, it lies in a failure to recognize both the existing communications between scientists who mainly focus on DSR and scientists who mainly focus on SSR, and our failure to improve and better develop these communications. By not fully understanding the interdependency of DSR and SSR, we assume a gap that is not really present, but we also fail to improve and develop a common understanding of DSR-SSR fusion as a means to more effectively advance the entire field of information systems.

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7. Appendix

Table. Comparison of Research Activities

Generic Research Phases and Activities	**Example - Pure Social Science Research**	**Example - Fusion Model of Design and Social Science Research**
Preliminary activity		
Choose phenomena/problem to study	Human cognition/decision making	Recommendation agent
	Review relevant knowledge of human behaviour (from prior Phase E if any)	Review relevant knowledge of artefacts and human behaviour (from prior Phase E if any)
A) Artefact Construction		
	No constructive activity.	Build/test/reflect iterations. Example imperative statements/procedures for agent: 1. Collect preferences 2. Collect options 3. Employ constraint algorithm 4. List all matches in ranked order. (involves formative testing).
B) Prescriptive theorizing		
Formalize prescriptive knowledge, including explanations/ justificatory knowledge. Include propositions that take descriptive form.	No prescriptive theorizing	Formalize prescriptive design theory/knowledge (see Gregor and Jones 2007). Contains some descriptive elements. Refer to optimization techniques and cognitive psychology theory as kernel theory. Example propositions: The Agent will identify all acceptable options from a list of 100 possibilities given 5 constraints. The agent is useful in human decision making.
C) Study Phenomena		
Observe phenomena and build theory	Study of natural phenomena	Study of artefacts in use and related human phenomena outside research development environment.
	Formalize descriptive theory. Refer to cognitive psychology theory explaining cognitive limits.	Formalize descriptive theory, taking into account empirical findings, and prior design and descriptive theory.
	Formulate proposition, e.g., A human decision maker can identify up to 10 acceptable options from a list of 100 possibilities given 5 constraints.	Revise design theory and propositions if needed to take account of empirical findings.
D) Tests of knowledge		
Test	Test propositions/hypotheses	Test propositions/hypotheses.
E) Descriptive theorizing		
Theorize	Formalize descriptive theory.	Formalize descriptive theory.