DISCOVERING THE SIGNIFICANCE OF SCIENTIFIC DESIGN PRACTICE: NEW SCIENCE WRAPPED IN OLD SCIENCE?

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Accepted to the SIG Prag Workshop on IT Artefact Design & Workpractice Improvement, 5 June, 2013, Tilburg, the Netherlands

Abstract

This paper aims at discussing and defining the achievement of significance in design science research. First it reviews the values and processes of old science and how this attacks complexity through analysis. It then explains how new science attacks complexity through synthesis. The paper goes on to argue that design science is burdened and limited in realizing its new science potential when wrapped in old science. This point is then demonstrated by two cases. The paper discusses how new science constitutes its significance. This discussion translates an old science framework of theory significance into a new science framework and uses the previous two cases to illustrate the framework. The paper provides groundwork on which design science research can realize its fundamental potential as new science.

Keywords: Design Science Research, Paradigm, Pragmatism, Wrappers.

1 Introduction

Distinctions between design science and behavioral research are helpful clarifying ways in which these two scientific paradigms differ (Osterle et al., 2011). These distinctions reflect a more fundamental set of more general distinctions that are already known and accepted in the philosophy of science. It may prove more helpful to position design science in the broader philosophy of science context, especially if this positioning reveals a better understanding of how design science makes contributions to scientific knowledge. The aim of this paper is to elaborate the ways in which scientific contributions can be recognized in design science.

We use the term science in its general English sense. There are many contrasting ways to define the concept of science. According to the Oxford English Dictionary, the dominant sense of the term in ordinary use regards branches of study that relate to the material universe and their laws. Under these laws, such sciences collect a systematic body of demonstrated truths and observed facts and include reliable methods for discovery. A long standing argument has held that science is a battleground for struggles between competing paradigms of science (Kuhn, 1970). This argument involves an assumption that a new, more fitting paradigm will eventually win the struggle to supplant an old "normal" paradigm. In this way, a new normal paradigm will arise.

In the philosophy of science, a distinction between *old science* and *new science* has been drawn in at least two ways. At its simplest, old science is chronologically defined. Old science developed before the Second World War, and is epitomized by the methods and body-of-truth of chemistry, mathematics or physics before that time. Old science operates in a disciplinary-based mode of basic science knowledge production. In contrast, new science arose after this period, and is epitomized by the methods and body-of-truth of computer science and information systems. New science operates in

a trans-disciplinary mode that crosses boundaries between academic disciplines and also between basic and applied science (Jansen et al., 2010).

A second way of distinguishing old from new science is more fundamentally defined. Old science is anchored to assumptions about nature that favor predictability, measurability, regularity, and clear cause–effect relationships (Luoma, 2006). New science encompasses concepts present in quantum mechanics, self-organizing systems, and complexity theory. Behavior depends on context, and context is beyond complete description. As a result cause and predictability cannot be completely known (Stumpf, 1995). Self-organizing systems involve different assumptions about pattern and regularity because these emerge spontaneously in systems unfettered by a causal relationship to central control (Luoma, 2006). Complexity theory involves different assumptions about observed regularities in nature because life by necessity has an internal world of sensations, perceptions, emotions, and impulses that complicate volition (Dent, 1999).

Absolutes rarely operate well in philosophy and the distinctions between old science and new science are indeed tendencies and not absolutes. For example, disciplines do not classify into old science or new science. For example, chemistry and physics are not old science and computer science and information systems are not new science. However, some predominance is recognizable. Chemistry can be seen as predominantly old science, and computer science can be seen as predominantly new science. But new science will operate in chemistry and old science will operate in computer science. Likewise, the labels cannot be categorical, but stand up better to scrutiny when viewed as a continuum instead of two distinct and mutually exclusive categories.

The experience thus far with the development of old science and new science suggests that the two competing paradigms may not be locked in a struggle to the death. Rather, the emergence of new science seems to be growing into a sustained coexistence with old science: a pluralist scientific state where two quite different versions of science co-operate more-or-less permanently (Lutz, 1989). Rather than achieving independent existence, there is a coexistence between the two approaches is similar to the development of multiple, sustained strategic directions following innovation (Van de Ven et al., 1989).

For researchers, this sustained co-existence may represent a synergy present in the current portfolio of old science and new science. As research communities acquire new science, the old and the new are often enlisted in helping modes, each advancing the other. Ethically, old science is not necessarily *bad*, nor even obsolete. New science is not necessarily *good*, nor even ascendant. These are different paradigms that can even be intertwined. Even this intertwining is both useful and laudable. However, advancement of new science may be retarded if researchers are *always* obliged to deliver only old science results and suppress new science results.

For practitioners, this sustained co-existence also inhabits the quest for scientific practice. Notions of scientific practice are driven by old science and new science. When used as a philosophy of science, pragmatism nests comfortably as a basis for scientific practice. It provides efficiency of practical application is a primary standard for scientific truth (Rescher, 2005). Such a standard surmounts the complexity of context without resort to analytical reduction, and aligns comfortably with the tenets of new science.

The remainder of this paper considers first how design science research appeals as new science and discusses whether design science research has been burdened and limited in realizing its potential. We then introduce the notion of *wrappers* and how these have been used in extending the old science paradigm. This introduction is followed by two cases demonstrating the potential of new science without old science wrappers. This potential leads to a discussion of what constitutes significant and interesting new science. We use a well-known framework of interesting theory (Davis, 1971) as a way to distinguish the interesting from the uninteresting, and we use the same two cases to show the use of the adapted framework. Finally we conclude that better recognition of old science wrappers, and appreciation for new science contributions will help design science research advance to its full potential as new science.

2 Design Science Research as New Science

Design science research is regarded as research paradigm in information systems anchored to construction of socio-technical artifacts as a means for discovery. Examples of such artifacts include decision support systems, technical tools, and methods (Gregor & Hevner, 2013). Both chronologically and functionally, the core of design science research falls into the realm of new science. Current views of design science research in Information Systems frequently anchor to Herb Simon's work on *The Sciences of The Artificial*, which dates chronologically from the 1960s (Simon, 1996). It also fits better with the functional descriptions of new science rather than old. Old science often operated in closed laboratories that excluded the outside universe. While this works for studies of gravity or light that absent human volition, it is unsuitable for design investigations that engage complex human situations, goals, and behavior (Johnson, 2010). Such design engagements often result in socio-technical artifacts that are computationally irreducible (the future states cannot be defined in equations because it is not possible to calculate every intermediate state).

Largely, the presence of human volition, innate in both the designers and the participants in socio-technical systems, yield the complexity on which new science thrives. This complexity often defies the tendency in old science to use analysis as a means for reducing complexity. Instead, design science (in particular) attacks complexity through synthesis (Simon, 1996). The synthetic viewpoint focuses on the interface between an inner and outer environment. The inner environment delivers a particular functionality to the outer environment across this interface. From a synthetic viewpoint, it is unnecessary to analyze how the inner environment operates. It is only necessary to describe the function and the interface that provides access to the function. (Hence, we sometimes find the old science criticism about incompletely described objects, Hooker, 2004.) Designers do not really need to reduce the complexity to engage it purposefully, only to describe functionality and interfaces in order to assemble problem solutions.

As a result, explanations in design science are different from old science. Old science uses analysis to learn by reducing complexity (i.e., taking its functionality apart). New science uses synthesis to learn by compiling complexity (i.e., assembling functionality together). Old science attached the greatest value to deductive explanations. Design science differs because it attaches the greatest value to functional or teleological explanations (Baskerville & Pries-Heje, 2010). Such explanations are content to engage nature in a functional way that preserves holism while at the same time delivering sustainability by innovating new purposes for both the natural and artificial world.

The new-science notion of delivering sustainability is particularly important in design science research. Design science is notable as following prescriptive and generative modes of research. In prescribing and generating new artifacts that join nature when situated, the world of both the natural and artificial is sustained by its further development. It is in this production of sustainability that design science research participates in, rather than observes, its setting.

3 Old Science Wrappers

We borrow the concept of a *wrapper* (sometimes called a *decorator*) from software engineering (Edwards et al., 2004). In that context, a wrapper is a component that reconciles mismatched subsystems, frequently for the purposes of adapting a new architecture above a legacy system. In this way, a wrapper extends the lifetime of old components by integrating them into new systems. Wrappers have attractive features. Wrappers do not alter the old or new systems. They reduce heterogeneity by offering a new interface as a possible standard. They enable new capabilities in a way that is transparent to both old and new systems and components. Wrappers also provide a smooth transition from old to new systems (Thiran et al., 2006).

We apply this concept of a wrapper to the phenomena that arise when we attempt to integrate design science research (a new science) with old science. The features described in the paragraph above

operate quite nicely, with one major exception. Software wrappers usually envelope old components in order to make them suitable for use within new systems. In the current state of design science research, it is sometimes wrapped in old science in order to make new science more suitable to old science. Figure 1compares the use of the software wrapper concept in software engineering (Figure 1a) with the use of the old-science wrapper concept in design science research (Figure 1b).

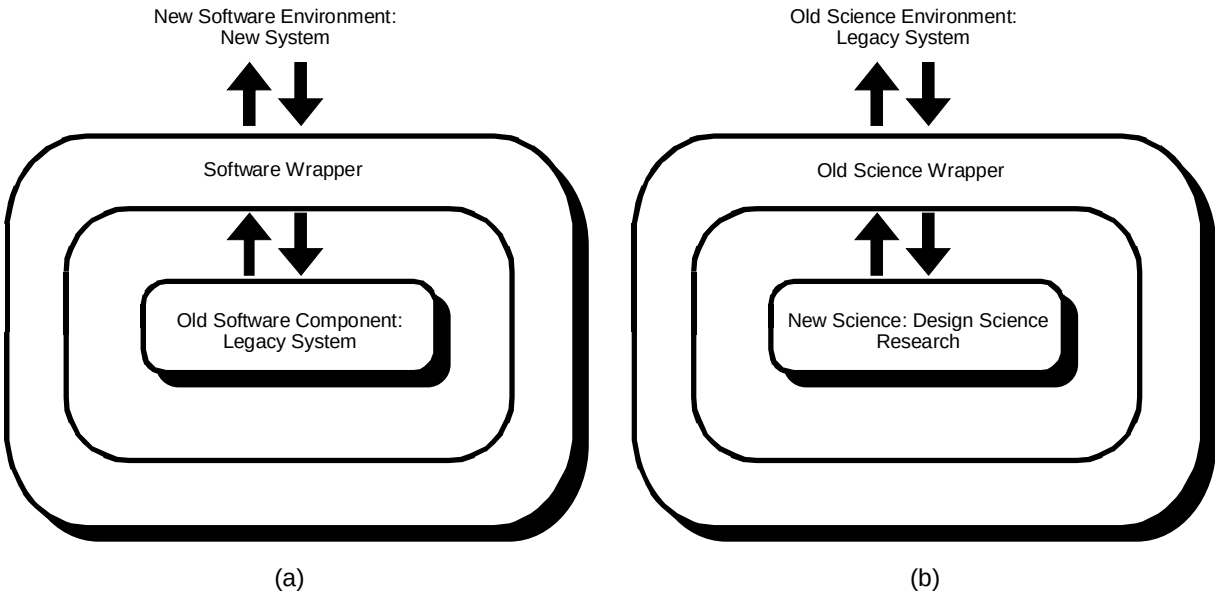

Figure 1. Comparing software and science wrappers (adapted from Edwards et al., 2004).

The old-science wrapper for design science research provides an old-science input and an old-science output as the context for design science research. These inputs and outputs might be operationalized in different ways. For example, these can consist of an emphasis on novel kernel theory and old-science evaluation.

Kernel theory is a component in design theory representing natural or social science theories that govern the design requirements or process (Walls et al., 1992) and serving as justificatory knowledge that gives a basis and explanation for the design (Gregor & Jones, 2007). Much of present-day descriptive theory relating to information systems is old-science psychological or sociological theory because of the human context into which information artifacts are placed. Even the use of socio-technical theories will often emphasize the central value of the knowledge contribution to the sociological aspects of the socio-technical theory. This context means that many kernel theories are fundamentally an old-science psycho-social *patch* in design science. The structure of design theory suggested by Walls, Widmeyer, El Sawy, Gregor and Jones is an adaptation from studies of old-science theory building (e.g., Dubin, 1978). Without kernel theory, design theory stands only on the legs of new science. By including an underlying psycho-social kernel theory, we aim to gain the predictability and deductive explanations of old science.

As the input channel for an old-science wrapper, the emphasis on the presence of old-science theory to undergird the actual design theory sets up design science research as a form of experimental setting. This setting tests not only the new-science design theory, but also the underlying old-science, psycho-social theory that was used to justify the design theory.

Evaluation is certainly a key element in design science research. Evaluation rigorously demonstrates the utility, quality, and efficacy of a design artifact use well-executed methods (Hevner et al., 2004). Evaluation certainly seems crucial in order to detect how a designed artifact changes the environment

in which it is placed. However, the notions of rigor are sometimes fundamentally another old-science patch. The majority of current design research evaluations assume the form of a technical experiment (Peffers et al., 2012) or as an iteration of abstraction and instantiation (e.g., Sein et al., 2011; Vaishnavi & Kuechler, 2007). Similarly to the testing of old-science theory, rigorous evaluation of a designed IT artifact requires the definition of measures, collecting of data, and analysis.

The old-science rigor does satisfy the old-science need for testing the prediction that the designed artifact will satisfy the design requirements and solve the problem. However, as the output channel for an old-science wrapper, this rigorous old-science evaluation is made necessary by the need to prove or support not just the design theory, but the psycho-social theory that motivated the design theory.

The old-science wrapper can consist of an input stage that pronounces a psycho-social kernel theory; and an output stage that rigorously evaluates the artifact and either supports or denies the kernel theory. In between, the new science stages pronounce a design theory, design an artifact, and instantiate an artifact. Figure 2 provides a graphical representation of such an old-science wrapper using an abbreviated adaptation of the Design Science Research Methodology for Information Systems Research detailed in Peffers et al (2008). An old-science wrapper governs the initiation of the project, in which problem identification and motivation also involves theorizing the situation in an old-science way. This old-science kernel theory drives a design science oriented search for requirements and components that provide the design theory for use in designing and instantiating an artifact. This design science effort produces technological "how-to" knowledge. This knowledge enables further understanding about how natural sustainability is being improved by the artifact. While such knowledge itself might be valuable in terms of new science, it is incomplete without further work in setting up an experimental demonstration of the artifact in its context. This demonstration delivers old-science measurement data to enable the analysis of the predictions set by the kernel theory and the outcome of the design science empirics. It also elaborates the new-science knowledge in terms of engagement, context integration, and natural sustainability. The rigorous evaluation further uses this data to satisfy the old-science needs for predictability, measurability, and causal claims. In this way, a kernel theory provides the old-science input, and the old-science evaluation provides the old-science output, while new science, the design science research, provides the empirical context and operations and new science knowledge outcomes.

New science can build forward from existing theory and may engage in a careful evaluation of the outcomes. The old-science wrapper arises when the main knowledge contribution value is derived from the use of design science as a means of studying the kernel theory. The old-science wrapper tests the kernel theory using data from the new-science study. It is the centering of knowledge composite of two activities that wrap the new-science: background theorizing and evaluating. As a result, the value of the new-science knowledge per se becomes marginalized.

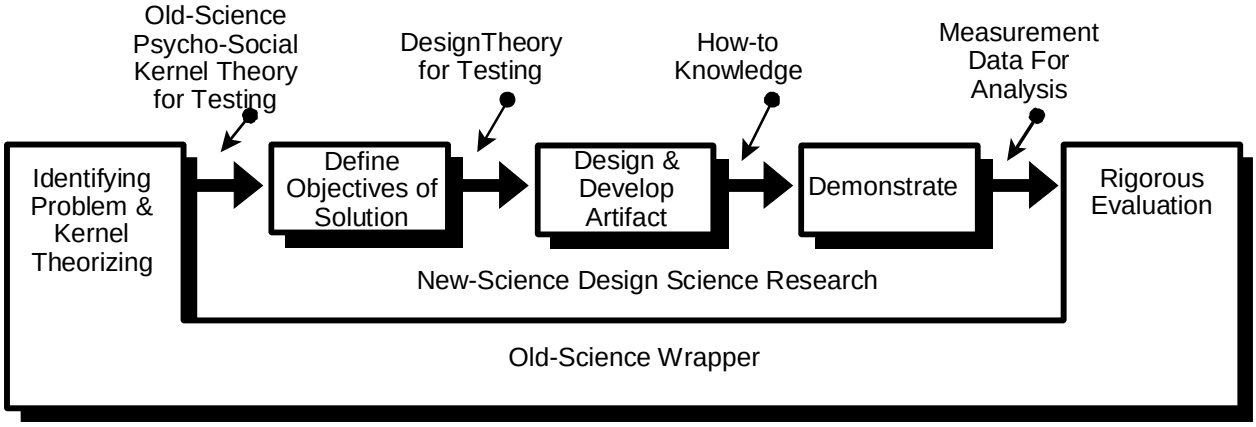

Figure 2. Old-Science Wrapping Design Science Methodology (adapted from Peffers et al., 2008).

4 Benefits of Old Science Wrappers

For information systems research, there are at least two prominent benefits from using old-science wrappers in the new-science field of design science research. These uses include the assimilation of design science research into the discipline of information systems. These uses also include the preservation of old-science research.

4.1 Assimilation

Old-science wrappers are intensely important features to enable the introduction of new-science into the scholarly discourse. For the field of information systems, the old-science wrappers are features of seminal work in design theory (e.g., Walls et al., 1992) and design science (e.g., Hevner et al., 2004). The wrappers provide an outward appearance by of design science research that has the look-and-feel of old science. But this appearance is *not* deception, it is conversion. The old-science wrapper provides quite genuine old-science value from design science research.

The old-science value of such studies is limited to confirmation of existing old-science theory where kernel theories are adopted in unaltered form. The theoretical novelty in such studies is limited to the knowledge proceeding from the kernel-theory-based design-theory situated in the new-science part of the research. Because such studies are confirmatory in the old-science sense, the knowledge dissemination venues are constricted. In other words, the established, top-level old-science journals will be unable to publish such work because confirmatory studies are not sufficiently significant contributions to knowledge.

The assimilation of design science research into the scholarly discourse is improved when the kernel theory is itself novel. This novelty can be necessary where existing kernel theory is not appropriate for grounding a design theory in the design situation. Such a situation makes it necessary to alter a known kernel theory (or create an altogether new psycho-social theory) as a basis for the design theory. Since the old-science evaluation process may provide convincing evidence for supporting the novel old-science kernel theory, the design science study may ultimately deliver significant old-science value for assimilation into old-science literature.

4.2 Preservation of Old-Science

The old-science wrappers are also useful in sustaining the validity of old-science values without denying the new-science values in design science research. For example, the presence of testable propositions or hypotheses (Gregor & Jones, 2007; Walls et al., 1992) integrate the old-science values of measurability and predictability with new-science values as part of design theory. Similarly to software wrappers, this integration preserves and updates important legacy components of old-science by making it compatible with new-science approaches.

The wrappers are a means for making design science research studies of value to old-science. Because such new-science approaches deliver values like engagement, holism, and sustainability, their incorporation updates old-science to bring such new-science features within old-science precincts. The wrappers are a means by which old-science gains new values such as engagement, holism, and sustainability.

Assimilation of new science and preservation of old science are both laudable and useful purposes for wrappers. The continuity of old science, represented by centuries of valuable discovery is essential to society today. Likewise, the contemporary acceptance of new science, with its potential trove of valuable new kinds of scientific knowledge, is equally essential to society today.

5 Problems with Old-Science Wrappers

There are at least two problem areas that arise in using old-science wrappers. The wrappers have an old-science appeal that can cloak the new-science value of design science research. Where the new-science is heavily cloaked within an old-science wrapper it can lead to confusion and identity reversal.

5.1 Design Process Constraints

Overemphasis on the old-science wrapper can lead to misunderstanding the importance of new-science aspects in a study. The old-science look-and-feel can repel potential proponents of a study who might otherwise be attracted to the values of new-science. For example, the notion that the act of designing can be somehow be programmed into an old-science method led early proponents of design science to reject the approach as unworkable (Cross, 2001). Similarly the constraints of old-science can prevent the achievement of design integrity that is associated with design breakthroughs (Brooks, 2010).

The emphasis on achieving old-science values (where the need to promote design science research to an old-science audience) makes it necessary to subdue the associated new-science values. In this way, the old-science wrappers may sometimes confuse observers with a presentation of design science research *as* old science. Such presentations may be usefully incomplete for the purposes of assimilation; but they may also damage the acceptance of design science research as a new-science.

5.2 Identity Reversal

Similarly, the design science research discipline as a whole may under-develop essential elements of design science where it becomes too completely absorbed in over-development of the old-science wrapper. Where an obsession with old-science eclipses the development of the new-science aspects of design science, the distinguishing features of design science are lost. For example, this loss arises where rigorous evaluation is promoted as the *only* scientific aspect of design science research. The new-science contributions of design science, such as the development of design theory and technical knowledge, are its distinguishing attributes. These identifying attributes become overlooked if the old-science wrappers are mistaken as essential elements of design science research.

In such a way, design science research identity loss follows the reversal of its essentials and its peripherals. Its essentials are new science: engagement, holism, and sustainability. Through the function of the wrappers, its peripherals are old science: measurability, predictability, and causality. Reversing the position of these values eliminates the distinction of design science research as new-science. It becomes instead old science with a new-science wrapper.

While wrappers are useful for assimilation of new science and preservation of old science, they create difficulty in identifying and appraising new science contributions in the presence of old science contributions. It is important to identify and separate the different paradigmatic contributions if the value of a new science, such as design science research, is to be made apprehensible separately from old science.

6 Cases

Following from the discussion above one can argue that new science can been burdened and limited in realizing its potential if always required to cloak itself in old science wrappers. This point is demonstrated by two carefully chosen cases. The first demonstrates how design science research is often wrapped as old science to develop significant old science contributions. The case is an example of Participatory Design (PD); a well-known but specific type of design research (Simonsen et al., 2010). The second case demonstrates how you can make a significant new science contribution and have real practical impact without having to use an old science wrapper. A downside of that is that you

may not get published in old science oriented journals. So the second case is not well published in a traditional sense; but that is exactly our point, and why this case was chosen..

6.1 Case #1 Wrapped Design Science Research

This case appeared in a special issue of *Information Technology and People* dedicated to design and diffusion of systems for human benefit. "Investigating the design process: Participatory design in agile software development", by Karlheinz Kautz (2011), presents work that "adds to the studies and theory of the design process…" (p. 230) and broadens "the perspective on design science research…" (p.233). The research delivers a case study of the development of an operations management system (OMS) for the water works of a large city (p. 223). The featured contribution of the paper is an "integrated framework of user participation" (Table 1, p. 222).

Here is a design science study that makes good use of old-science wrappers. With reference to problem identification and kernel theorizing (see Figure 2), the research operates from a descriptive research question, "We pose the research question how customers and users participate in the design activities in agile development in practice and study participatory design in agile development as a particular instance of a design process in information systems development." (p. 218). It advances theoretically from "complex adaptive systems theory" (p. 217) and socio-technical theory (p. 222).

The research report unfolds in a manner consistent with old-science reports. Following a thorough literature review there is a method section emphasizing empirical rigor. For example, "The empirical data for the case study was collected in semi-structured, open-ended interviews, which were conducted by a team of two researchers in a three days period on the development site. The research team performed 12 interviews with 11 individuals" (p. 222). These interviews covered "a representative sample of key players and future users in the customer organization" (p. 222).

The analytical values of old science get a degree of emphasis:

- "The analysis revealed that …" (p. 217)
- "Our further analysis will then be based on the following constitutive concepts" (p. 221)
- "… we have used our integrated theoretical framework which consists of salient concepts … as one background for our data analysis." (p. 222)
- "… we found in our case genuine customer and user participation … We empirically confirm and extend …" (p. 229)
- "Analyzing the different user roles …" (p. 230)
- "Our analysis shows that …" (p. 233)
- "By drawing on innovation theory we found …" (p. 233)

This analysis led to an integrative framework that provided old science explanatory theory about why participatory design contributes to project success. (Mainly it was because participation invoked organizational innovation.) The framework comprised four variance elements: User focus, forms of participation, participating stakeholder roles, and purpose of participation. From an old-science viewpoint, the success of the case offered results similar to a field experiment that supported the proposed theories about how customers and users participate. It provided the necessary old science rigor for the evaluation of the case results (see Figure 2).

While the care in the construction of the old science wrapper would comfort reviewers seeking the old science value in the study, the work retains a design science core. For example, the case work was also described as "engaged research", not in new science modes like action research or design science, but in old science modes, "… a participative form of research for seeking advice and perspectives of key stakeholders to understand and theorize about a complicated problem" (p. 221). The outcomes include a clear pronouncement that the framework could also be constituted as a design theory of participatory design in agile development. The framework had direct practical relevance in showing

how to organize actual user participation in the design activities during agile development in order to drive a project to result in a process and product that all stakeholder groups appreciate.

The descriptive old science framework that proceeded from the study is also offered as a prescriptive tool for designing user participation in the future. "In this way, we make a contribution to the establishment of a theory of participatory design in agile development, which comprises elements of an analytical, an explanatory, and a design theory… " (p. 218). Ultimately we find a design theory with potentially high utility that project managers could use to engage users in agile development (Table 1, p. 222). Likewise the user participation roles could easily be converted into a functional design: "Here are the roles that you as user can take on when participating in agile development' (Table III).

The design science could have been stronger in this study if the empirical work had actually instantiated the design theory as a prescriptive tool in designing user participation. From a new science perspective, the study outcome was an untried design theory. It is still a hypothetical design theory. The perspective from the old-science wrapper is less formative, providing empirical backing for its theoretical claims. However, by producing a design theory, it is an example of design science research that has been wrapped in old science. Without the old science wrapping, the functional explanations and the prescriptive value of the framework might have been an insufficient contribution to draw sufficient new-science attention. Also, the synthesis of the framework from the underlying case might not have been as compelling without the detailed analysis of the empirical data. Comparatively, the old-science contribution is stronger and better developed than the new-science contribution, which helps explain the solid placement in the journal literature. Until new-science contributions are better understood or more strongly valued, the old science wrapper is important to frame a compelling old science contribution.

6.2 Case #2 Unwrapped New Science Research

Today, it appears difficult to publish design science research without an old science wrapper. While there are common examples of wrapped work, there are few, if any, examples in DESRIST proceedings or in information systems journals publishing design science research.

There are better examples in the social sciences. For example, in psychology work in the solutions-focused approach stands on its new science value without the necessity of an appeal to old science. The core idea in this approach assumes that deep and rigorous analysis does not often contribute to an understanding that is useful in designing a functional solution for the future. Instead the researcher (i.e., the designer) together with customer or client (i.e., the user) aims at describing a desirable future situation. Once that future situation is described and agreed then the next thing is to identify the first step available today in the direction of the desirable future situation.

The solutions-focused approach was originally developed in psychology and used for coaching. One mantra of the approach holds that talking about problems creates more problems; but talking about solutions creates solutions (see http://solutionsurfers.dk/ citing Steve de Shazer as the source of this mantra). Hence the focus on synthesizing functional solutions (i.e. on solution design). Examples of solutions-focused applications are found in the published research in psychology and therapy by Insoo Kim Berg (Berg & De Jong, 1996) and Steve De Shazer (Shazer & Berg, 1997; Shazer et al., 1986).

The solutions-focused approach has spread to other areas. For example, Paul Jackson & Mark McKergow (2002), transferred the approach to organizational development. In Norway the *LØFT-instituttet* is an institute dedicated to working with the solutions-focused approach. Among the publications from this institute is one that describes how best to apply the solutions-focused approach ("LØFT på sitt beste", Langslet, 2012) including its use for organizational therapy.

But is the work on this approach design science research? Indeed, the authors do not refer to it as such. However, it does provide a model for delivering significant new science contributions. The various publications clearly use functional explanations and demonstrate this functionality with case studies.

Typically these are studies of successful family therapy or organizational development. The solutions approach is clearly prescribing solution design and the desirable future situation will nearly always include an artifact: product or process.

The solutions-focused approach has mainly developed in a community-of-practice within psychology, therapy, and among many consultants. There is a plethora of books available on the approach. But relatively few research articles have been written. In the introduction to a journal special issue, we find that “Research has been minimal” even though the approach “can be described as experimental and research oriented from the beginning” (Shazer & Berg, 1997, p. 121).

The solutions-focused approach is an excellent model for a new science basis for design science research. It has delivered significant contributions that rescued many people and organizations from dire situations. It is an approach that has never been wrapped in an old science wrapper. So it elegantly illustrates the potential of pure new science as a future anchor for design science research significance.

7 Discussion

You may have been provoked by our statement that Case #2 was “pure” and a good example of “new science”. How do we know? This leads to the question of what is interesting or significant?

Here we are left to search for the raw significance in new science itself, not its significance to old science. We are so attuned to the notions of old science significance, that we require old science wrappers to develop old science significance, enabling us to have a “aha!” moment in old science terms. This was demonstrated above in Case #1 (Kautz 2011). But what should be this moment in new science?

Part of our understanding of significance in old science arises from appraisal of theory within old science. Davis (1971) examined the notion of “interesting theories” in terms of sociology of knowledge. But Davis did not stop at the “theoretical dimension” alone, but also considered a “practical dimension”. Davis’ practical dimension could provide insight into how we recognize the significance in new science.

For example, Davis noted that a proposition becomes worthy when it denies the truth of a part of our routine assumption-ground. In the practical dimension, this proposition is worthy because it denies the usefulness of a part of our present practical activity and insists we should take up a new practical activity instead.

The basic technological knowledge that proceeds from design science research often regards a novel class of artifacts. A translation of Davis’ practical dimension might read, “this new class of artifacts is worthy because it denies the usefulness of some part of an old class of artifacts and insists we should take up this new class of artifacts instead.” For example, the arrival of smart phones and the development of their apps is significant because denies the continued usefulness of developing some web artifacts, and insists that we take up development of mobile apps instead.

Davis’ rhetorical analysis of this structure in old science is:

“(1) The author articulates the taken-for-granted assumptions of his imagined audience by reviewing the literature of the particular sub-tradition in question ("It has long been thought . . ."). (2) He adduces one or more propositions that deny what has been traditionally assumed ("But this is false . . ."). (3) He spends the body of the work proving by various methodological devices that the old routinely assumed propositions are wrong while the new ones he has asserted are right ("We have seen instead that . . ."). (4) In conclusion, he suggests the practical consequences of these new propositions for his imagined audience's on-going social research, specifically how they ought to deflect research onto new paths (Further investigation is necessary to . . .).” (Davis, 1971, p. 311)

A design science technological knowledge translation of this rhetorical analysis is:

(1) Articulate the design theory for a taken-for-granted class of artifacts (current practice)

(2) Adduce an opposing design theory that denies the continued usefulness of the requirements or functions of the taken-for-granted design theory (obsolesce current practice)
(3) Build and evaluate an instantiation of the new design theory demonstrating the opposing design theory leads to a more useful artifact (breakthrough)
(4) Project the consequences of adopting the new class of artifacts (dissemination).

How is this different? In old science, knowledge about nature is often assumed to be *perpetua*. In old science, denying existing assumptions often meant showing how these were "merely phenomenological pretense" (Davis, 1971, p. 311) and that the proposed new assumptions were ontologically superior. In new science, technological knowledge is assumed to be *ephemera*. This knowledge may last only until nature changes, perhaps only as long as the observation itself. In design science, like other predominantly new science disciplines, denying existing assumptions usually means showing how these have expired because the old environment has changed into a new environment, and that existing class of artifacts is no longer suitable. Existing assumptions have become obsolete. Table 1 translates Davis' index of the interesting into terms more attuned to a new science such as design science.

Character of Phenomena	Category	Description
Single	Organization	A disorganized (unstructured) phenomenon has become instead an organized (structured) phenomenon.
		An organized (structured) phenomenon has become instead a disorganized (unstructured) phenomenon.
	Composition	Assorted heterogeneous phenomena have become instead composed of a single element.
		A single phenomenon has become instead composed of assorted heterogeneous elements.
	Abstraction	An individual phenomenon has become instead a holistic phenomenon.
		A holistic phenomenon has become instead an individual phenomenon.
	Generalization	A local phenomenon has become instead a general phenomenon.
		A general phenomenon has become instead a local phenomenon.
	Stabilization	A stable and unchanging phenomenon has become instead an unstable and changing phenomenon.
		An unstable and changing phenomenon has become instead a stable and unchanging phenomenon.
	Function	A phenomenon that functions ineffectively as a means for the attainment of an end has become instead a phenomenon that functions effectively.
		A phenomenon that functions effectively as a means for the attainment of an end has become instead a phenomenon that functions ineffectively.
	Evaluation	A bad phenomenon has become instead a good phenomenon.
		A good phenomenon has become instead a bad phenomenon.
Multiple	Co-relation	Unrelated (independent) phenomena have become instead correlated (interdependent) phenomena.
		Related (interdependent) phenomena have become instead uncorrelated (independent) phenomena.
	Co-existence	Phenomena that can exist together have become instead phenomena that cannot exist together.
		Phenomena that cannot exist together have become instead phenomena that can exist together.
	Co-variation	A positive co-variation between phenomena has become instead a negative co-variation between phenomena.

Character of Phenomena	Category	Description
		A negative co-variation between phenomena has become instead a positive co-variation between phenomena.
	Opposition	Similar (nearly identical) phenomena have become instead opposite phenomena.
		Opposite phenomena have become instead similar (nearly identical) phenomena.
	Causation	The independent phenomenon (variable) in a causal relation has become instead the dependent phenomenon (variable).
		The dependent phenomenon (variable) in a causal relation has become instead the independent phenomenon (variable).

Table 1. Design Science Interesting Index (adapted from Davis 1971).

For example, the function of university libraries is to provide accessible knowledge repositories to students. Libraries are recognizing that digital technologies have not only reshaped the needs of students, and that the typical cognitive approach by such students has changed (Sweeney, 2005). As a result, the traditional means by which libraries deliver this functionality to students (stacks of paper books and journals) is no longer effective. This corresponds to the Single-Function-Index entry in Table 1, "A phenomenon that functions effectively as a means for the attainment of an end has become instead a phenomenon that functions ineffectively." The very interesting result is that libraries have instantiated new phenomena on their premises, (digital journal subscriptions and Internet cafes) to better deliver the required functionality. This design is significant because libraries should stop the primary engagement as stacks of paper books and journals, and instead be engaged in delivering easy connectivity to online subscriptions.

Davis' notion of interesting is not the only measure of significance or contribution. Weick (1989) considered other "selection criteria" by which we choose important theories. Using such indices of interesting can have problems because by this definition, interesting theories are often tightly anchored to disconfirming recent past experience. Accordingly such a criterion can make truly original groundbreaking theories (that have no prominent basis in past design experience) seem trivial. However, among these criteria, "that's interesting" is prominent because of its flashy and emotional nature. This is a proper starting point to consider determining significance in the raw results of a new science like design science research.

7.1 Case #1 Wrapped Design Science Research

Kautz (2011) indicates that prior user participation found that user participation in agile development was limited because end users do not naturally assume a customer role. Kautz's work asserts the opposite: genuine customer and user participation in agile development (p. 229). This assertion hints at a possible new-science contribution: a single, function contribution that a phenomenon that functioned ineffectively as a means for the attainment of an end has become instead a phenomenon that functions effectively. That is, end users who were known previously to function ineffectively as customers in agile development have instead become effective in this role.

As a consequence of this interesting change in the environment of agile development, Kautz is able to develop an "integrated framework of user participation" (Table 1, p. 222) for agile development. In our analysis of case #1 above we showed how the design science would have been made more interesting if the empirical work had actually instantiated the design theory as a prescriptive tool in designing user participation. Such an instantiation would provide empirical backing for the single-function change in the environment that now allows the design of user participation in agile projects which in the past were known to be ineffective and to an extent random. But this most interesting aspect, in the new science sense, was left empirically unresolved in favor of the treatment of the old-

science contribution of the user participation framework as an analytical tool. The focus is on the relationships between the phenomena (1) contingencies of the situation, (2) user participation techniques and (3) user participation methods. An instantiation might have provided the more functional discovery of exactly how these relationships are now available to agile development approach designers. The significance in a new science sense remains quite speculative although the main contribution, found in the old science wrapper is satisfactorily established by the paper. It proved unnecessary to pursue the new science contributions beyond the margins because the research is instead justified by its old science value.

7.2 Case #2 Pure Design Science Research

The problem we find with case #2 is not dissimilar. A preoccupation with the lack of old science wrappers brings the ultimate oversight. The experts assume an old science view that "research has been minimal" while at the same time apologizing for their new science preoccupation with being "… busy inventing a rather radical approach …" (Shazer & Berg, 1997, p. 121). They neglect to recognize the new science contribution in the successes and examples they report. For example Molnar & de Shazer (1987) report the success of a new type of therapeutic intervention that stabilizes the client. In the Davis' framework, this would fall into *Single* and *Stabilization* because an unstable and changing phenomenon has become instead a stable and unchanging phenomenon.

The solutions-focused approach primarily focuses on achieving a desirable future situation instead of (over-) analyzing the current situation. This approach is interesting because it stabilizes (hence *Single* and *Stabilization* in our Table 1). But it is also interesting because it functions as therapy: a way out of a hopeless situation for individuals as well as organizations. Hence it is interesting as *Single* and *Function* where "A phenomenon that functions ineffectively as a means for the attainment of an end has become instead a phenomenon that functions effectively" (Table 1).

Case #2 illustrates that new science can prove to be just as interesting as old science, but the tense of the theoretical revolution moves from "is" to "becomes". Seen from this perspective there is less reason for cloaking new science in old science wrappers and thereby risking oversights of the new science potential of design science research.

Both cases illustrate frameworks that invoke practical their practical application as their standard of scientific truth. As a consequence both cases are of interest in relation to scientific practice as framed in new science. However, Case #1 features an old science wrapper that provides an entrée in to the more traditional scientific literature. Case #2 rests mainly on its new science alone. As a result, Case #2 is anchored tightly to pragmatism, while Case #1 relies not only on pragmatism but also on analytical interpretation.

8 Conclusion

This paper set out to discuss and define the essential nature of design science research contributions. We encountered a paradigmatic view on "old science" and showed how "new science" is clearly different; e.g. in its approach to complexity where new science seeks mainly synthesis and deemphasizes analysis.

New science has been burdened and suppressed from realizing its potential by having to "cloak" itself in old science "wrappers". While these wrappers are useful in a number of ways, it can lead to lesser quality in actual design science contributions because of the contrasting emphasis on the contributions in the old-science wrapper. By centering on the layering of old-science analytical rigor, we lose the focus on the new-science synthesis and useful functionality.

While this may be a current struggle in information systems, other fields may be overcoming this situation and gaining more focus on new-science contributions. Taking a model approach from psychology, such as the solutions-focused approach demonstrated the potential of pure, unwrapped

new science. This review clarifies how the theoretical importance of old science, represented in an "index of the interesting", shifts from the analytic to the synthetic.

As community interested in design science research, it is important to maintain the connections with new-science paradigm in which the research resides. While wrapping design science research in old-science wrappers is useful at times, the distinctive characteristics of this research genre lie in its new-science attributes. Significant design science research is primarily significant new science, and only secondarily significant as old science.

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