The DRIVES (Design Research for Innovation Value, Evaluation, and Sustainability) Model of Innovation

Alan R. Hevner[1], Brian Donnellan[2], and Jack Anderson[3]

[1] University of South Florida
ahevner@usf.edu
[2] National University of Ireland Maynooth
brian.donnellan@nuim.ie
[3] Chevron Corporation
jack.anderson@chevron.com

Abstract. We propose a new innovation model that leverages Design Science Research concepts and principles. The goal of this paper is to outline the six stages of DRIVES with brief descriptions of the activities performed during the stages. An industrial consortium provides some observations on the application of DRIVES for innovation.

Keywords: Design Science Research, Innovation, Information and Communications Technologies and Systems.

1 Introduction

The synergistic relationship between widely used innovation processes, such as IDEO [8] and the Design Science Research (DSR) paradigm [7] has been identified and explored. In Anderson et al. [1], we use a real-life case study of an IDEO-based Innovation Cycle in Chevron to perform a gap-analysis with DSR. The results of the study suggest that there are key insights that can be drawn from the DSR concepts and guidelines that can potentially impact and improve organizational innovation processes. Based on our initial gap analysis, we find five key areas of potential DSR contribution.

1.1 Artifacts

The Innovation literature focuses on the contribution of the artifact to the application environment and the 'adopting unit.' The case study indicates that innovative artifacts can take on many forms of abstract knowledge (e.g. models, architectures, methods), as well as, physical or systems-based instantiations. Current innovation processes, as exemplified by the application of the IDEO innovation approach in Chevron, focus on the outcome of the overall process rather than the artifacts that are created at each stage of the process. The identification and analysis of artifacts created throughout the entire innovation process may well be a core differentiator between DSR and Innovation.

M. Helfert and B. Donnellan (Eds.): EDSS 2012, CCIS 388, pp. 144–154, 2013.

1.2 The Central Role of Evaluation

DSR guidelines stress the importance of evaluation of utility, quality, and efficacy. Apart from an effort by Venkatesh and Davis [13] to establish evaluation criteria for disruptive innovations, there is little evidence of extensive use of evaluation methods in the innovation process. It is not well defined how innovators appropriately select evaluation methods to provide convincing evidence of their artifact's utility and qualities. We posit that the emphasis on evaluation in DSR could have great potential to inform innovation processes.

1.3 Rigor

DSR guidelines stress the application of rigor in the development process – as a means of enhancing the quality of the artifact that emerges from the process. A corresponding emphasis on rigor in construction and evaluation is not to be found in the Innovation literature. We would argue that rigor in innovation processes is just as essential as in DSR. Attention to the most appropriate and effective techniques for building and evaluating the innovation is critical to an innovation's acceptance and success in the market place.

1.4 Search

In the case study, only contributions that are new and unique to the group executing the Innovation Challenge are in focus, so there is an onus on members of the innovation community to perform relevant searches. While we found a number of similarities between the search processes for design artifacts in DSR and the Chevron innovation process, we believe that further study is needed to fully understand the relationships between the methods for searching complex solution spaces for innovations and design solutions.

1.5 Contributions and Value

DSR guidelines stress that clear and verifiable contributions in the areas of the design artifact, design theories, and/or design methodologies are required. In parallel the innovation cycle stresses the drive for solutions that are new, value-added contributions to the organization applying them. The case study looked at the value of artifacts throughout the innovation cycle which lead to important findings that are useful to business, as understanding the business value of the innovation process is one of the major problems facing organizations today. As established innovation processes do not usually analyze the value of all ideas (usually only ideas that pass final approval at the end of the process are analyzed for value) our analysis led us to interesting discoveries of potential value of artifacts throughout the cycle.

2 The DRIVES Model of Innovation

Drawing from this gap analysis of Design Science Research and the Chevron Innovation Cycle, we propose a DSR influenced innovation model termed DRIVES

(Design Research for Innovation Value, Evaluation, and Sustainability). The application of DSR concepts and guidelines to the discovery and development of innovative artifacts can be described in the following six-stage innovation model.

2.1 Challenge

Define and describe the challenge to be addressed by the Innovation Process. This stage elicits the essential requirements information for the desired innovation and structures the innovation task for subsequent stages of DRIVES.

a. Use appropriate techniques and models to formulate state representations of the current environment and the goal environment.
b. Expose the problem or opportunity to be addressed by the desired innovation. How would the innovation transform the current state to the goal state?
c. Describe the *Design Space* via parameters that can be manipulated by heuristic search algorithms. The design space can be viewed as the collection of all possible designs and requirements. Conceptually, then, we can imagine that the space is partitioned between a few known and many unknown designs. The design process begins with a search of this space in order to identify one or more particular positions, which can be referred to as *Design Candidates*.
d. The search for high fitness design candidates and artifacts requires utilizing available means to reach desired ends while satisfying laws in the design space.
e. The principle issue in this stage is *Complexity*. Any real-world problem or opportunity will necessarily be embedded in a complex environment making its solution a *wicked problem*.
f. Designers may react to complexity in the innovation process in many different ways. They may choose to decompose the problem into sub problems, each of which then becomes the basis of its own task. They may choose to approach the problem iteratively, using the repetitive build-evaluate cycles that are typical of agile programming. They may choose to reframe the problem entirely, perhaps using analogy to look at the problem in an entirely different way.

2.2 Ideation

The goal in this stage is to search the design space and generate feasible candidate designs. The essence of this stage is *Creativity* to produce novel ideas in the form of artifacts.

a. In the early stages of design discovery each new artifact is "an experiment" that "poses a question to nature" [10 p. 114]. Existing knowledge is used where appropriate to build the artifact; however, most often the requisite knowledge is nonexistent. As previously noted, such artifacts may be symbolic or physical representations of our selected location in the design space
b. *Providing evidence of design feasibility* - Can the proposed design be implemented and does the proposed design meet the requirements? Building feasibility artifacts moves designs across the unknown/known partition.

c. This stage can be compared to the traditional 'brainstorming' phase of innovation. However, our concept of ideation is more constrained by the activities of the previous 'challenge' stage. Candidate designs, e.g. ideas, must provide evidence of feasibility before acceptance.

2.3 Refinement

This stage contains the core 'build – evaluate' design cycle of Design Science Research. Feasible candidate designs are refined during rigorous cycles of building out the design artifact and subjecting it to appropriate evaluation methods that demonstrate its strengths and weaknesses to achieve the goal state.

a. The internal design cycle is the heart of any DSR project. This cycle of research activities iterates rapidly between the construction of an artifact, its evaluation, and subsequent feedback to refine the design further. Simon [12] describes the nature of this cycle as generating design alternatives and evaluating the alternatives against requirements until a satisfactory design is achieved. The design cycle is where the hard work of DSR is done. During the performance of the design cycle a balance must be maintained between the efforts spent in constructing and evaluating the evolving design artifact. Both activities must be convincingly based in relevance and rigor. Artifacts must be rigorously and thoroughly tested in laboratory and experimental situations before releasing the artifact into use. This calls for multiple iterations of the design cycle before contributions are identified in the next stage.
b. Successful innovation also requires the intellectual *Control* to refine creative thinking into practical solutions. Such control is dependent on the cognitive skills of reason and judgment. In essence, maintaining intellectual control of the evolving Build activities in DSR results in the reduction of uncertainty. Drawing from ideas of problem structuring and complexity, we identify two types of uncertainty. A major challenge in problem structuring is differentiating between these two situations and then applying the most effective controls in order to refine the selected design candidates to use artifacts.
    i. Reducible Uncertainty – The problem can be decomposed into sub-problems that can be addressed independently via control techniques of learning, planning, abstraction, solution specification, and composition of solutions.
    ii. Irreducible Uncertainty – The problem has no clear decomposition and must be solved as a whole via control techniques like scenario generation and risk management.
c. The process of design refinement asks the following key Build questions:
    i. *Providing evidence of the value of the design* - Does the design offer benefits unmatched by competing design candidates? Here the objective becomes to establish an ordinal valuation that can be used to rank candidate designs.
    ii. *Determining the most effective representation of the design* – How can we best communicate the intricacies of the design to the implementers (e.g. architects, programmers).

iii. *Constructing the actual use artifacts* – How do we guide the construction of the use artifact? As examples - a blueprint is a construction artifact that serves to guide the physical construction of a house; source code is a construction artifact that serves to generate the programs that are distributed to users.

d. At the conclusion of this stage, there should exist only a very few surviving design candidates that will move onward to use in the target field environment.

2.4 Contribution

Once the refinement stage generates an innovative design artifact, a time of reflection is needed to understand how the new design contributes to the human knowledge base. Such reflection is extremely valuable during innovation to appreciate how truly innovative the ideas are or whether we are simply reinventing wheels.

a. Contributing to human knowledge is seen as the key criterion for the credibility of the innovation effort. The appropriate and effective consumption and production of knowledge are fundamental issues that innovation teams should consider throughout the innovation process – from initial problem selection, to the use of sound research methods, to reflection, and to communication of research results in journal and conference articles. The potential impacts of rigorous DSR are lost or marginalized when knowledge contributions are inadequately positioned and presented.
b. IT artifact plays a key role in knowledge contribution. In general, the term artifact refers to a thing that has, or can be transformed into, a material existence as an artificially made object (e.g., model, instantiation) or process (e.g., method, software). Many IT artifacts have some degree of abstraction but can be readily converted to a material existence; for example, an algorithm converted to operational software. In contrast, a theory is more abstract, has a non-material existence, and contains knowledge additional to the description of a materially existing artifact. The construction of an artifact and its description in terms of DSR concepts and principles can be seen as steps in the process of developing more comprehensive bodies of knowledge or design theories.
c. A DSR Knowledge Contribution Framework as presented by Gregor and Hevner [5] posit a DSR knowledge contribution framework as an effective way to understand and position a DSR project's research contributions. Clearly identifying a knowledge contribution is often difficult in DSR because it depends on the nature of the designed artifact, the state of the field of knowledge, the audience to whom it is to be communicated, and the publication outlet. In addition, the degree of knowledge contribution can vary: there might be incremental artifact construction or only partial theory building, but this may still be a significant and publishable contribution. The size of the knowledge increase could be offset by the practical impact in a knowledge area.

2.5 Use

The goal in this stage is to actualize the candidate artifacts via prototyping or other forms of implementation and study in the target environment. Field evaluations are performed to understand the utility and fitness of the artifact in context.

a. The output from the previous stages must be returned into the environment for study and evaluation in the application domain. The field study of the artifact can be executed by means of appropriate technology transfer methods such as action research [11].
b. The results of the field testing will determine whether additional iterations of the refinement stage are needed. The new artifact may have deficiencies in functionality or in its inherent qualities (e.g., performance, usability) that may limit its utility in practice. Another result of field testing may be that the requirements input to the innovation process were incorrect or incomplete with the resulting artifact satisfying the requirements but still inadequate to the opportunity or problem presented. Returning to the Challenge stage will commence with feedback from the environment from field testing and a restatement of the research requirements as discovered from actual experience.
c. The use artifacts are divided between pilot test instances—for which returning to the design cycle of refinement is intentionally left open as a possibility—and release use instances, for which further redesign is not immediately anticipated. While this conceptual scheme obviously maps directly to IT artifacts such as software, it should be recognized that organizations frequently employ a phased roll out of non-technology artifacts, such as organizational structures or incentive plans, with the same notion that the design may later be tuned based upon early experience.
d. The results of this stage will indicate whether the proposed artifact is a satisfactory result of the innovation process or whether the process will need to return to a previous stage for more work.

2.6 Sustainability

The final stage of the innovation process moves beyond the current usefulness of the design artifact to a fuller appreciation of the sustainable value of the innovation. Here we briefly discuss several characteristics of a sustainable innovation. The appropriate selection of sustainability criteria will depend on the innovation environment and goals.

a. Decomposibility - The seminal work that launched the study of design science is Herbert Simon's [12] *The Sciences of the Artificial*. The second half of the book is largely devoted to explaining why systems tend to evolve from nearly decomposable subsystems. Indeed, even under the existing DSR goals, decomposability is likely to exert a strong influence on design quality and would therefore be evaluated as part of the design. In addition, such systems tend to be easier to construct, since work on individual components can be conducted separately.

b. Malleability - Often enhanced by decomposability, the malleability of an artifact represents the degree to which it can be adapted by its users and respond to changing use/market environments [6]. MIS research has demonstrated that users frequently employ tools for unintended purposes. We would expect that such adaptation would allow designers to evolve artifacts to support these uses more effectively. Tools such as scripting languages are sometimes incorporated into application designs to provide power user-malleability. User-malleability itself can be divided into levels, such as customization, integration and extension. Here customization refers to the ability of a design to be tailored to a user's preferences. Integration involves the ability to conveniently share the capabilities of one artifact with another, creating a resultant artifact with capabilities beyond those of either original design. The ability to create mash-ups of web components on a single page is an example of this capability. Extension means adding new capabilities to an artifact.
c. Openness - Another design characteristic that has the potential to impact design fitness is the degree to which artifacts are open to inspection, modification, and reuse. Open designs—particularly when combined with decomposability and malleability—encourage further design evolution by making it easier both to see how an artifact is constructed and to modify existing components of the artifact. For example, an information system created as an open source application has a significant advantage over a proprietary design in terms of its ability to evolve rapidly.
d. Embeddedness in a Design System - We would expect design artifacts that are the product of a sustainable design system environment to evolve more rapidly than artifacts that are produced in a context where design is an unusual activity. This particular source of fitness can sometimes act as a counterweight to openness, as organizations with highly effective research and development activities may be reluctant to open up their designs and may use legal measures—such as patents and copyrights—to discourage unauthorized parties from evolving the original designs. A design system can also manifest itself as a community of users and designers, providing contributors with intrinsic motivation to contribute.
e. Novelty - A design may be considered novel if it originates from an entirely new region of the design space. Once such a design candidate has proven viable, other design candidates from the same region are likely to follow in an attempt to locate the local peak on the fitness landscape. A particular challenge that novel design artifacts present is that the creative process through which they are envisioned may not meet the criterion of usefulness and rigor suggested by the original guideline and the potential benefits of the design may be hard to evaluate. A genuine new invention is a difficult goal for DSR research projects and we can expect few research contributions to be true inventions [5]. However, exploration for new ideas and artifacts should be encouraged regardless of the hurdles.
f. Interestingness - Normally, a design artifact is created in order to explore or demonstrate some specific purpose. From time-to-time, however, an artifact may demonstrate unexpected emergent behaviors that are worthy of subsequent investigation and the creation of subsequent artifacts. An artifact may also be

constructed in an unexpected way that intrigues other designers or design researchers. We characterize such designs as *interesting*. While there is likely to be considerable overlap between designs that are interesting and designs that are novel, the two characteristics are not identical. We have framed the benefits of novelty in terms of contributing to the diversity of the design landscape. Broadly speaking, the benefit of an interesting design is its propensity to diffuse. In fact, requiring a design to be interesting may serve as a limitation on its novelty.

g. Elegance - In many areas of design, such as architecture, consumer products and apparel, there is an ongoing tension described as form versus function. Function relates to practical usefulness. Form, in contrast, describes aesthetic elements such as appearance that do not necessarily serve a useful purpose, yet nevertheless increase the user's utility. The characteristic of an IS design artifact that corresponds to form might best be referred to as *elegance*. Like quality, elegance is hard to define in a rigorous manner and yet characteristics that might be associated with it—such as compactness, simplicity, transparency of use, transparency of behavior, clarity of representation—can all lead to designs that invite surprise, delight, imitation, and enhancement. Equally important, they can cause a design artifact whose usefulness has yet to be demonstrated to endure.

3 Observations and Future Directions

Current methods of innovation, such as IDEO, are being criticized for a lack of rigor and 'scientific' results in their execution [4]. Our goal in this paper is to propose the DRIVES model of innovation that incorporates the rigor of Design Science Research into an innovation process. In this concluding section, we provide observations of an industrial consortium to the DRIVES model.

During 2012, a consortium of innovation leaders from four major corporations conducted an analysis of innovation processes and methods. This Innovation Management Research (IMR) Group participated in a research project on the measurement of innovation management processes. The four corporations represented in the group leverage a similar framework for innovation based on the well-known IDEO innovation cycle. The IMR group also leveraged research and lessons learned from participation in the Innovation Management Working Group of IVI (Innovation Value Institute). In their initial exposure to the DRIVES model, they identified two significant areas that are considered ripe for benefit from DSR concepts: the Challenge Stage and the Refinement Stage. Thus, the following analysis focuses on observations from these two areas.

3.1 Challenge Stage Observations

The DRIVES model Challenge Stage maps to the first two steps in the IDEO Innovation Cycle: Understand and Observe. The goals of these steps are to secure an understanding of the challenge at hand, to develop artifacts that are used to enable participants to understand the problem so that they can contribute new ideas to the solution of the problem or challenge, and to develop metrics to measure the success of the effort.

The set of common tools utilized by the IMR Group to understand the **current environment** in innovation workshops include:

- Forcing factor analysis
- Root Cause Analysis
- Interviews of people involved in the current state
- Capability Assessment -- current state
- Organization metrics
- Project Look-Backs and Postmortems
- Value Stream Mapping
- Problem Statistics
- Success Statistics
- Technology review
- Pain point identification
- Benchmarking analysis of peer organizations – current state

Tools to identify the **goal environment** include:

- Vision statement – (example new market expansion)
- Benchmarking Analysis of peer organizations – desired/future state
- Capability assessment – future/desired state
- Best method Analysis
- Interviews of people involved in the current environment

Once the current environment and the goal environment are captured, the question of how the innovation would transform the current state to the goal state must be answered. This statement hits an important area of potential value of DSR to innovation. This is an area where the IMR Group observes that the art of creative thinking is leveraged rather than having a methodical practice that can measured. At this stage the option is usually done by "Connectors" as described by the IMR Group: people who observe the desired innovation and make the mental connection that it might have great value in the environment of focus. The IMR Group described this mental connection as an "epiphany".

Perhaps because of the time required to expose the desired innovation to the environment – or because the Connector realizes the epiphany might have many applications beyond their own perspective – this epiphany state is one of the primary catalysts for engagement of innovation management. The agility of the innovation management area allows rapid exposure and the ability to bring in people with different points of view from various parts of the organization. If time or organizational structure are not factors then the activity might be managed by traditional research and development.

The IMR Group wonders if DSR might help in this area via:

- Epiphanies are sometimes hard to understand as they are not documented in formal ways. Can DSR help us learn more about this area?
- Epiphanies by subject matter experts or influential business leaders are accepted and provide over 50% of the work managed by innovation teams of the IMR Group. But the group believes there are lots of epiphanies that are not heard or understood. Can DSR help us learn more about this area?

As a deliverable of the Challenge stage, the IMR Group recommends the generation of a single artifact, a Challenge Scoping Document. This document would include:

- the frame for the innovation activity including in and out of scope statements
- timing
- business / functional area for investigation and application
- resources available for effort including people involved in creative thinking about it
- success factors
- proposed methodologies to be applied to the challenge

3.2 Refinement Stage Observations

The IMR Group believes the DRIVES Refinement Stage is another key area where DSR can better support industrial innovation. There is a significant concern that if innovation artifacts not framed properly the likelihood that ideas and solutions might be missed is high.The IMR Group believes the following methods can be leveraged in refinement:

- Idea expansion (group tests a submitted ideas and augments as appropriate)
- Idea Evaluation: sorting by success criterion
- Idea Theme identification
- Rapid Prototyping
- Proposal Documentation

Output from the refinement stage often triggers another round of ideation to expand creative thinking, which in turn is followed by another cycle of refinement. The IMR Group knows that there are many areas where DSR might add value to Innovation in this refinement stage as it takes concepts generated by the art of creative thinking in the ideation stage and judgments are applied to identify the wheat from the chaff. But participants also know that great new ideas and concepts can be lost without clear and rigorous criteria for the build-evaluate cycle as dictated by DSR.

3.3 Future Directions

The IMR Group will remain engaged with this research on applying DSR concepts to innovation processes. The group is actively studying all stages of the DRIVES model for important value-added ideas for corporate innovation processes. This research is being undertaken in conjunction with the Innovation Value Institute (www.ivi.ie) [2-3]. Applying the principles of engaged scholarship [9, 14], innovation is being investigated using a design process with defined review stages and development activities based on the DSR guidelines advocated by Hevner et al. [7]. Using a case study approach supported by semi-structured interviews, researchers will investigate the practice of innovation in some of its consortium members. A focus of the research is the design decisions and rationale underpinning innovation processes so that the relationship between DSR and Innovation might be better understood.

References

1. Anderson, J., Donnellan, B., Hevner, A.: Exploring the Relationship between Design Science Research and Innovation: A Case Study of Innovation at Chevron. In: Helfert, M., Donnellan, B. (eds.) EDSS 2011. CCIS, vol. 286, pp. 116–131. Springer, Heidelberg (2012)
2. Curley, M.: Managing Information Technology for Business Value. Intel Press (2004)
3. Curley, M.: Introducing an IT Capability Maturity Framework. In: Cardos, J., Cordeiro, J., Filipe, J. (eds.) ICEIS 2007. LNBIP, vol. 12, pp. 63–78. Springer, Heidelberg (2007)
4. Govindarajan, V., Trimble, C.: The Other Side of Innovation: Solving the Execution Challenge. Harvard Business Review Press, Cambridge (2010)
5. Gregor, S., Hevner, A.: Positioning and Presenting Design Science Research for Maximum Impact. Management Information Systems Quarterly 37(2), 337–355 (2013)
6. Gregor, S., Jones, D.: The Anatomy of a Design Theory. Journal of the Association of Information Systems 8(5), Article 2, 312–335 (2007)
7. Hevner, A., March, S., Park, J., Ram, S.: Design Science in Information Systems Research. Management Information Systems Quarterly 28(1), 75–105 (2004)
8. Kelley, T., Littman, J.: The Art of Innovation: Lessons in Creativity from IDEO, America's Leading Design Firm. Doubleday, New York (2001)
9. Mathiassen, L., Nielsen, P.: Engaged Scholarship in IS Research. Scandinavian Journal of Information Systems 20(2) (2008)
10. Newell, A., Simon, H.: Computer Science as an Empirical Inquiry: Symbols and Search. Communications of the ACM 19(3), 113–126 (1976)
11. Sein, M., Henfredsson, O., Purao, S., Rossi, M., Lindgren, R.: Action Design Research. Management Information Systems Quarterly 35(1), 37–56 (2011)
12. Simon, H.: The Sciences of the Artificial, 3rd edn. MIT Press, Cambridge (1996)
13. Venkatesh, V., Davis, F.: A Theoretical Extension of the Technology Acceptance Model: Four Longitudinal Field Studies. Management Science 46, 186–204 (2000)
14. Van de Ven, A.: Engaged Scholarship: A Guide for Organizational and Social Research. Oxford University Press, Oxford (2007)