Korea University

Design Science in e-Business Research

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Dominant Paradigms in IS Research

Positivism

- Quantitative research
- Descriptive, predictive, explanatory
- Quest for universal laws
- Concerned with the empirical testability of theories
  - Causal models (if it's not about cause-and-effect, it's not Science)
- Assumptions:
  - Existence of a priori fixed relationships within phenomena
  - Regular patterns of causation
  - Independent from human mind (objective, factual)

Interpretivism

- Qualitative research
- Interpretive
- No search for universal laws
- Draws heavily on researchers' experiences and interpretations
- Assumptions:
  - Nondeterministic (value judged by researchers)
  - Dependent from human mind (subjective, interpretive)

Behavioral Science Paradigm

Positivist Perspective

Science < > True
Science = Useful

- A ue ful mod l (Th o y) is b tter t an "T u h"
- An Exp r ien t w t hou a Th o y is m aninge ss
- Da a have no m aninge xe pwt hre sp ct d bt t b o y f om which t e ysp ing

- What is a Th o y?
  - Causal Model
  - Internally Consistent
  - Explains and/or Predicts
  - Testable

Theorizing in IS Research

Theorizing that Newton's theory of gravity holds for IT, and testing it by dropping a PC from an office window in the MIS department is obviously not valuable

March and Smith 1995

Theorizing in IT research must explicate those characteristics of the IT artifact operating in its environment that make it unique to IT and require unique explanations

March and Smith 1995

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Behavioral Science vs. Design Science

Behavioral Science Paradigm

- Its root in natural science research method
- Reactive with respect to technology
- Takes technology as "given"
- Seeks to develop and justify theories that explain or predict organizational and human phenomena (descriptive & predictive)

Design Science Paradigm

- Its root in engineering and the sciences of the artificial (Simon 1996)
- Proactive with respect to technology
- Seeks to create and evaluate innovative IT artifacts intended to solve identified organizational problems (prescriptive)
- Problem solving paradigm
- The resultant IT artifacts extend the boundaries of human problem solving and organizational capabilities by providing intellectual as well as computational tools
  - Theories regarding their application and impact will follow their development and use
  - IT artifacts often define the object of study in behavioral IT research
  - Such artifacts are not exempt from natural laws or behavioral theories

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Development of IS Research

1. Positivist Science molded IS field
   - 1970s – 1980s
   - MIS Quarterly was launched in 1977
2. Interpretive Science entered IS field
   - 1990s
   - Information Systems Research was inaugurated in 1990
3. Design Science plays an active role in IS field
   - 21st Century
   - IS researchers begin to recognize the discipline's core property – IT artifacts

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Design Science by Herbert A. Simon

Engineering, medicine, business, architecture, and painting are concerned not with the necessary but with the contingent – not with how things are but with how they might be – in short, with design

Simon 1996, p. xii.

The professional schools can reassume their professional responsibilities just to the degree that they discover and teach a science of design, a body of intellectually tough, analytic, partly formalizable, partly empirical, reachable doctrine about the design process

Simon 1996, p. 113.

Design like science is a tool for understanding as well as for acting

Simon 1996, p. 164.

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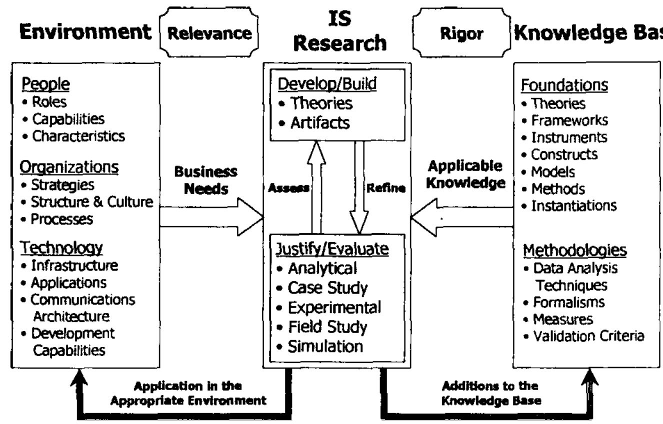
Types of Design-Science Research

- A combina ion of te chnology-base d a t ifac s o ganiza ional a t ifac s and p ople-base d a t ifac s are n essa y t o addre ss IT p oble ms in IS Re se a ch

	Examples
Technology Based Artifacts	• System conceptualization and representations • Practices • Technical capabilities • Interfaces
Organization Based Artifacts	• Structures • Compensation • Reporting relationships • Social systems
People Based Artifacts	• Training • Consensus building

Routine Design vs. Design-Science Research

Research Framework



MIS Quarterly, March 2004

Design-Science Research Guidelines

Guideline 1	Design as an Artifact
Guideline 2	Problem Relevance
Guideline 3	Design Evaluation
Guideline 4	Research Contributions
Guideline 5	Research Rigor
Guideline 6	Design as a Search Process
Guideline 7	Communication of Research

Guideline 1 – Design as an Artifact

Design-science research must produce a viable artifact in the form of a construct, a model, a method, or an instantiation

- A p o pos fu l IT a t ifac ca n be a d dre ss an impo t a n o ganiza ional p oble m
  - The IT artifact is the "core subject matter" of the IS field (Orlikowski and Lacono 2001)
  - Theories of long-lived artifacts and their representations are fundamental to the IS discipline (Weber 2003)

Artifacts

- Constructs [redacted]
  - Vocabulary and Symbols
  - e.g., ER Model, Unifying Modeling Language, Critical Success Factor
- Models [redacted]
  - Abstractions and Representations
  - Descriptive
    - e.g., simulation
  - Prescriptive
    - e.g., optimization
- Methods [redacted]
  - Algorithms and Practices
  - Represent the process aspect of design artifacts
  - Algorithmic (execution by a computer)
    - e.g., Heuristic search and case-based reasoning procedures
  - Procedural (execution by a human)
    - e.g., System development methodologies
- Instantiations [redacted]
  - Implemented and Prototype Systems – Realization of an artifact in its environment
  - Demonstrate feasibility both of the design process and of the designed product
    - Poses a question to nature, and its behavior offers clues to the answer (Newell and Simon 1975)
  - Enables the researcher to better understand the behavior of the artifact itself and its usability by its intended constituency – how the artifact affects and how users appropriate it

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Guideline 2 – Problem Relevance

> The objective of design science in IS research is to develop technology-based solutions to important and relevant business problem

- Th re e vane of any d ign-sci ne re s a the fot is wt hre sp tt o a cons t a h communt y
- Cons t e h communt y
  - Practitioners who plan, manage, design, implement, operate, and evaluate information systems
  - Practitioners who plan, manage, design, implement, operate, and evaluate the technologies that enable their development and implementation
- To b re e vah t d its communt y...
  - Research must address the problems faced and the opportunities afforded by the interaction of people, organizations, and IT

> Organizations spend billions of dollars annually on IT, only too often to conclude that those dollars were wasted (Keil and Robey 1999)

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Guideline 3 – Design Evaluation

> The utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods

- Evalua ion is a c ucial compon t of t e re e a ch p ce ss
- Th busin ss e nvi onm t e s tablishe s t e re quire m n ts upon which t e e valua ion of t e a tifac is base d
- Th e valua ion of a d sign a tifac re quire s
  - Definition of appropriate metrics, and ...
  - *Possibly the gathering and analysis of appropriate data*
- A d sign a tifac is *complete* and *effective* wh n it sa isfie s t e re quire m nts and constr ints of t e p oble m it was m ant t solve .
- S yle

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Design Evaluation Methods

- Observational [redacted]
  - Case Study – studies artifact in depth in business environment
  - *Field Study – monitors use of artifact in multiple projects*
- Analytical [redacted]
  - Static Analysis – examines structure of artifact for static qualities (e.g., complexity)
  - Architecture Analysis – studies fit of artifact into technical IS architecture
  - Optimization – demonstrates inherent optimal properties of artifact or provide optimality bounds on artifact behavior
  - Dynamic Analysis – studies artifact in use for dynamic qualities (e.g., performance)
- Experimental [redacted]
  - Controlled Experiment – studies artifact in controlled environment for qualities (e.g., usability)
  - Simulation – executes artifact with artificial data
- Testing [redacted]
  - Functional (Black Box) Testing – executes artifact interfaces to discover failures and identify defects
  - Structural (White Box) Testing – performs coverage testing of some metric (e.g., execution paths) in the artifact implementation
- Descriptive [redacted]
  - Informed Argument – uses information from the Knowledge Base (e.g., relevant research) to build a convincing argument for the artifact's utility
  - Scenarios – constructs detailed scenarios around the artifact to demonstrate its utility

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Guideline 4 – Research Contributions

Effective design-science research must provide clear and verifiable contributions in the areas of the design artifact, design foundations, and/or design methodologies

- Ultimate assessment for any research is "What are the new and interesting contributions?"
- Novelty, Generality and Significance of the designed artifact
- Three Potential Types of Contributions
  - The IT Artifact
    - The artifact must enable the solution of heretofore unsolved problems
    - Extends the Knowledge Base, or
    - Applies existing knowledge in new and innovate ways
  - Foundations
    - Creative development of novel, appropriately evaluated constructs, models, methods, or instantiations that extend and improve the existing foundations in the Knowledge Base
  - Methodologies
    - Creative development and use of evaluation methods (measures) and new evaluation metrics

Guideline 5 – Research Rigor

Design-science relies upon the application of rigorous methods in both the construction and evaluation of the design artifact

- Rigo adde se st b way in whichre e a this condute d
- D sign-sce re re e a thofe re les on ma b matical fo malism, btu ...
- Rigo must b ase se dwt he sp tt d b applicabilt yand g er alizabilt yoft b at ifat
  - An overemphasis on rigor can lessen relevance
  - Possible and necessary for IS research to be both rigorous and relevant
- Rigo is d r ie df ont b e fe tie ue oft b Knowle dg Bae
  - Theoretical Foundations
  - Research Methodologies
- Knowle dg of b havio at b oe sande mpi ical wo ls ae e e sa y t cconstr ut ande valute d sign dat ifat s

Guideline 6 – Design as a Search Process

The search for an effective artifact requires utilizing available means to research desired ends while satisfying laws in the problem environment

- D sign ise se tially a e a thp ce ssl cdiscove r ane fe tie soltu ion t oa p dte m
- M ans,e nds, and laws ae p dte rande nvi onm nt d p nd hand inva iably involve ce tivit yand innova ion
  - Means
    - The set of actions and resources available to construct a solution
  - Ends
    - Goals and constraints on the solution
  - Laws
    - Uncontrollable forces in the environment

Effective design requires knowledge of both the application domain (e.g., requirements and constraints) and the solution domain (e.g., technical and organizational)

Guideline 7 – Communication of Research

Design-science in IS research must be presented effectively both in technology-oriented as well as management-oriented audiences

- Te chnology-o ie te daudie nce s
  - Detail enough to be constructed (implemented) and used
    - Build a cumulative knowledge base
    - Repeatability of the research project
    - Further research extensions
- Manag em nt-o ie te daudie nce s
  - Detail enough to determine whether the organizational resources should be committed to constructing (or purchasing) and using the artifact
  - The emphasis must be on
    - The importance of the problem
    - The novelty and effectiveness of the solution approach

Design Science in e-Business Research

> The goal of design science is to solve problems by introducing into the environment new artifacts, the availability of which will induce their spontaneous employment by humans and thus, coincidently, cause humans to abandon their previous problem-producing behaviors and devices
>
> Fuller 1992

- The construction of new, innovative artifacts can have far reaching impacts on organizations
- These artifacts may change the environment that previously posited laws or principles are rendered irrelevant or inapplicable

- Design science research is concerned with changing existing situations into desired ones; with how things ought to be in order to attain goals and to function
- We argue that design science is an applicable and necessary paradigm for e-Business research

In Quest of Complementary Research Cycle

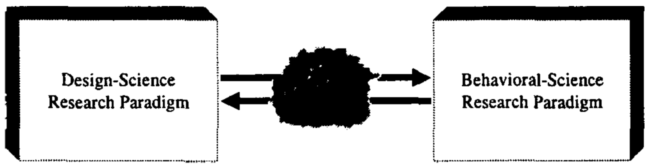
> Given the artificial nature of organizations and the information systems that support them, the design-science paradigm can play a significant role in resolving the fundamental dilemmas that have plagued IS research: rigor, relevance, discipline boundaries, behavior, and technology
>
> Lee 2000

- The Dangers of a Design-Science Research Paradigm
  - Overemphasis on the technological artifacts and a failure to maintain an adequate theory based, ...
  - Potentially resulting in well-designed artifacts that are useless in real organizational settings
- The Dangers of a Behavioral-Science Research Paradigm
  - Overemphasis on contextual theories and failure to adequately identify and anticipate technological capabilities, ...
  - Potentially resulting in theories and principles addressing outdated or ineffective technologies

- IS design-science research should be aligned with real-world production experience
- We encourage collaborative industrial/academic research projects and publications based on such experience

A Call for Synergistic e-Business Research

e-Biz research lies at the intersection of people, organizations, and technology
It is both an organizational and a technical discipline



- e-Biz research must be both proactive and reactive with respect to technology
- We argue that both design-science and behavioral-science paradigms are needed to ensure the relevance and effectiveness of e-Biz research
- Important problems in the theory and practice of e-Business will be resolved only by a combination of design and behavioral science paradigms

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