Design Science Research in Information Systems

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Outline

- Design Science Research in IS
  - Rethinking Design in IS Research Projects
  - MISQ Paper Impacts
- Three Cycles of Design Activities
- DSR Knowledge
- Publication Schemata
- Exemplar DSR Projects
- Issues and Future Directions
- Questions and Discussion

Research Portfolio

- Ph.D. in Computer Science from Purdue
- Faculty Member at Minnesota (CS), Maryland (IS), and USF (IS)
- Database Systems
  - Query Optimization on Distributed Database Systems
  - Query and File Allocation Algorithms
- Software Engineering
  - Cleanroom Software Engineering
  - Metrics and Software Testing
- Information Systems Analysis and Design
  - Health Care Data Warehousing and Data Mining
  - Service-Oriented Systems and Cloud Computing
- Recent Assignment with U.S. National Science Foundation (NSF)

Design Science Research

- Sciences of the Artificial, 3rd Ed. – Simon 1996
  - A Problem Solving Paradigm
  - The Creation of Innovative Artifacts to Solve Real Problems
- Design in Other Fields – Long Histories
  - Engineering, Architecture, Art
  - Role of Creativity in Design
- Design Research in Information Systems
  - Tradition of Industry-based Action Research (Europe)
  - Building of Artifacts (Design) not valued in Academic IS
    - Journals and Conferences
    - P&T and Salary
  - Rethink Positioning of Design Research
    - Elevate Visibility and Stress Relevance

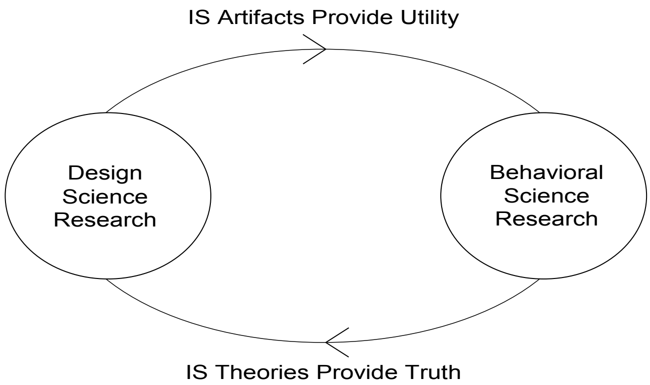
MISQ 2004 Research Essay

- A. Hevner, S. March, J. Park, and S. Ram, "Design Science Research in Information Systems," *Management Information Systems Quarterly*, Vol. 28, No. 1, March 2004, pp. 75-105.
- Historically, the IS field has been confused about the role of design (technical) research.
- Technical researchers felt out of the mainstream of ICIS/MISQ community.
  - Formation of Workshop on Information Technology and Systems (WITS) in 1991
- Initial Discussions and Papers
  - Iivari 1991 – Schools of IS Development
  - Nunamaker et al. 1991 – Electronic GDSS
  - Walls, Widmeyer, and El Sawy 1992 – EIS Design Theory
  - March and Smith 1995 from WITS 1992 Keynote
  - Encouragement from IS Leaders such as Gordon Davis, Ron Weber, and Bob Zmud
- Allen Lee, EIC of MISQ, invited authors to submit essay on Design Science Research in 1998
  - Four Review Cycles with multiple reviewers
  - Published in 2004

IS Research Framework

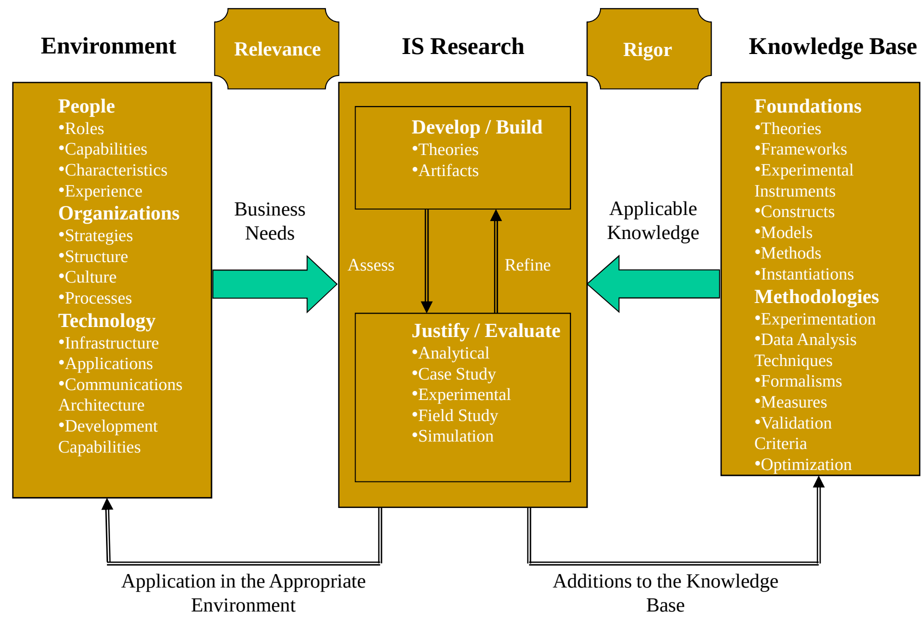
- Information Systems (IS) are complex, artificial, and purposefully designed.
- IS are composed of people, structures, technologies, and work systems.
- Two Basic IS Research Paradigms
  - Behavioral Research – Goal is Truth
  - Design Research – Goal is Utility

IS Research Cycle



Design Science

- Design is a Artifact (Noun)
  - Constructs
  - Models
  - Methods
  - Instantiations
- Design is a Process (Verb)
  - Build
  - Evaluate
- Design is a Wicked Problem
  - Unstable Requirements and Constraints
  - Complex Interactions among Subcomponents of Problem and resulting Subcomponents of Solution
  - Inherent Flexibility to Change Artifacts and Processes
  - Dependence on Human Cognitive Abilities - Creativity
  - Dependence on Human Social Abilities - Teamwork



May 2011 Vienna DSR Seminar 9

Guidelines for DS Research in IS

- Purpose of Seven Guidelines is to Assist Researchers, Reviewers, Editors, and Readers to Understand and Evaluate Effective Design Science Research in IS.
- Researchers will use their creative skill and judgment to determine when, where, and how to apply the guidelines to projects.
- All Guidelines should be addressed in the Research.

May 2011 Vienna DSR Seminar 10

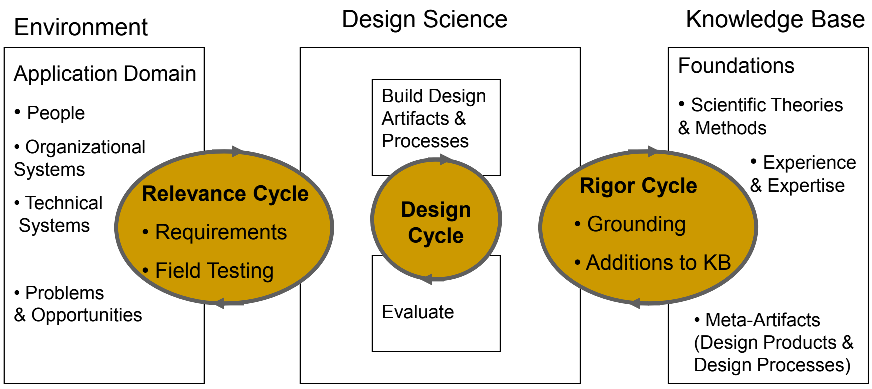
Design Research Guidelines

Guideline	Description
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.
Guideline 2: Problem Relevance	The objective of design-science research is to develop technology-based solutions to important and relevant business problems.
Guideline 3: Design Evaluation	The utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods.
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.
Guideline 5: Research Rigor	Design-science research relies upon the application of rigorous methods in both the construction and evaluation of the design artifact.
Guideline 6: Design as a Search Process	The search for an effective artifact requires utilizing available means to reach desired ends while satisfying laws in the problem environment.
Guideline 7: Communication of Research	Design-science research must be presented effectively both to technology-oriented as well as management-oriented audiences.

MISQ Paper Impacts

- Professional Impact
  - Raised visibility of Design Science Research in IS
  - Identified interdisciplinary synergies (e.g., CS, Engineering design, management, etc.)
  - Identified relationships among research paradigms (e.g., behavioral, economic, etc.)
- Citation Impact
  - Over 1800 citations on Google Scholar
- International Impact
- Doctoral Education and Research Impact
- Conference Impacts
  - Introduction of Design Science Research in Information Systems & Technology (DESRIST) Conference
    - First Doctoral Consortium in 2008
    - DESRIST 2011 in Milwaukee, USA, May 2011
    - DESRIST 2012 in Las Vegas, USA, May 2012
  - Design Science Track at ICIS
- Journal Impacts
  - Special Issue of MISQ in 2008 on Design Science Research
  - New SE and AEs for Design Science Papers at MISQ
  - Design Science Papers encouraged at ISR, JAIS, JMIS, etc.

Three Cycles of DS Research



The Relevance Cycle

- The Application Domain initiates Design Research with:
  - Research requirements (e.g., opportunity, problem, potentiality)
  - Acceptance criteria for evaluation of design artifact in application domain
- Field Testing of Research Results
  - Does the design artifact improve the environment?
  - How is the improvement measured?
  - Field testing methods might include Action Research or Controlled Experiments in actual environments.
- Iterate Relevance Cycle as needed
  - Artifact has deficiencies in behaviors or qualities
  - Restatement of research requirements
  - Feedback into research from field testing evaluation

The Rigor Cycle

- Design Research Knowledge Base
  - Design Theories
  - Engineering Methods
  - Experiences and Expertise
  - Existing Design Artifacts and Processes
- Research Rigor is predicated on the researcher's skilled selection and application of appropriate theories and methods for constructing and evaluating the artifact.
- Additions to the Knowledge Base:
  - Extensions to theories and methods
  - New experiences and expertise
  - New artifacts and design processes

Design Theories

- Is an Information Systems Design Theory (ISDT) essential for rigorous design research?
- I would contend that the answer is No
- Design research can be grounded on:
  - Behavioral Theories
  - Opportunities, Problems, Potentialities
  - Analogies, Metaphors
  - Creative Inspiration and Insight
- Partial ISDTs are the result of artifact design and evaluation

Design Cycle

- Rapid iteration of Build and Evaluate activities
  - The hard work of design research (1% inspiration and 99% perspiration - Edison)
- Build – Create and Refine artifact design as both product (noun) and process (verb)
- Evaluation – Rigorous, scientific study of artifact in laboratory or controlled environment
- Continue Design Cycle until:
  - Artifact ready for field test in Application Environment
  - New knowledge appropriate for inclusion in Knowledge Base

Useful Knowledge

- *It is clear from the preceding that every "art" [technique] has its speculative and its practical side. Its speculation is the theoretical knowledge of the principles of the technique; its practice is but the habitual and instinctive application of these principles. It is difficult if not impossible to make much progress in the application without theory; conversely, it is difficult to understand the theory without knowledge of the technique.* - Diderot, "Arts" in the *Encyclopedie* (1751-1765) (Quoted in (Mokyr 2002))
- Forms of Useful Knowledge:
  - Descriptive Knowledge (denoted Ω) – The 'What' knowledge about phenomena (natural, artificial, human) and the laws and regularities among phenomena
  - Prescriptive Knowledge (denoted Λ) – The 'How' knowledge of human-built artifacts and prescriptive design theories

Useful Knowledge

Ω – Descriptive Knowledge

- **Phenomena** (Natural, Artificial, Human)
  - Observations
  - Classification
  - Measurement
  - Cataloging
- **Sense-making**
  - Natural Laws
  - Regularities
  - Principles
  - Patterns
  - Theories

Λ – Prescriptive Knowledge

- **Artifacts**
  - Constructs
    - Concepts
    - Symbols
  - Models
    - Representation
    - Semantics/Syntax
  - Methods
    - Algorithms
    - Techniques
  - Instantiations
    - Systems
    - Products/Processes
- **Design Theory**

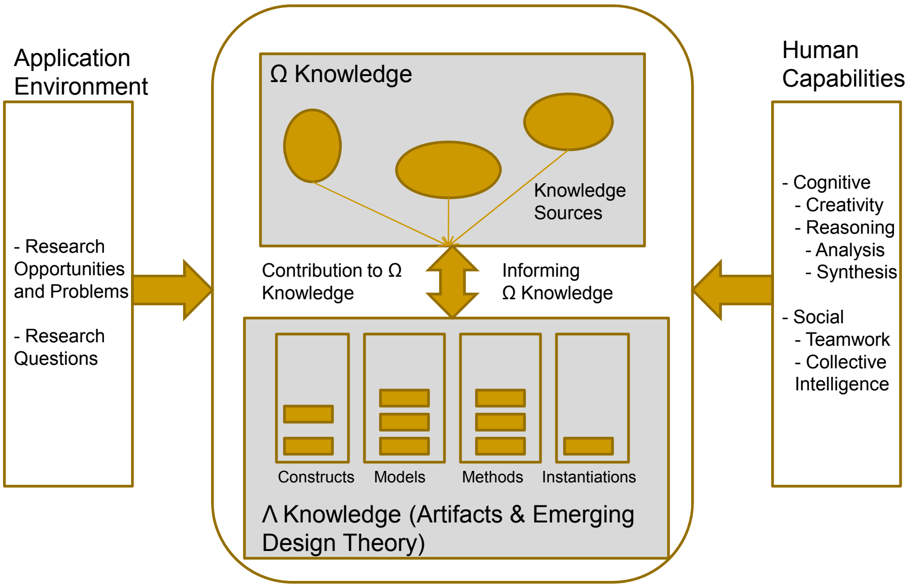
Nature of the DSR Artifact

- The Artifact Problem Space must be separated from the Knowledge Contributions made by DSR
- Artifact Problem Space as presented in IS Design Theory:
  1. Purpose & scope (Defines the goals of the DSR project – What is the artifact and what is its scope? Relevance?)
  2. Constructs (Artifact *constructs*)
  3. Principles of form and function (Artifact *models and methods*)
  4. Artifact mutability (Describes impact of artifact change)
  5. Testable propositions (Truth hypotheses)
  6. Justificatory knowledge (Kernel theories from Ω)
  7. Principles of implementation (from Ω)
  8. Expository instantiation (Artifact *instantiation*)
  9. Principles of evaluation (from Ω)

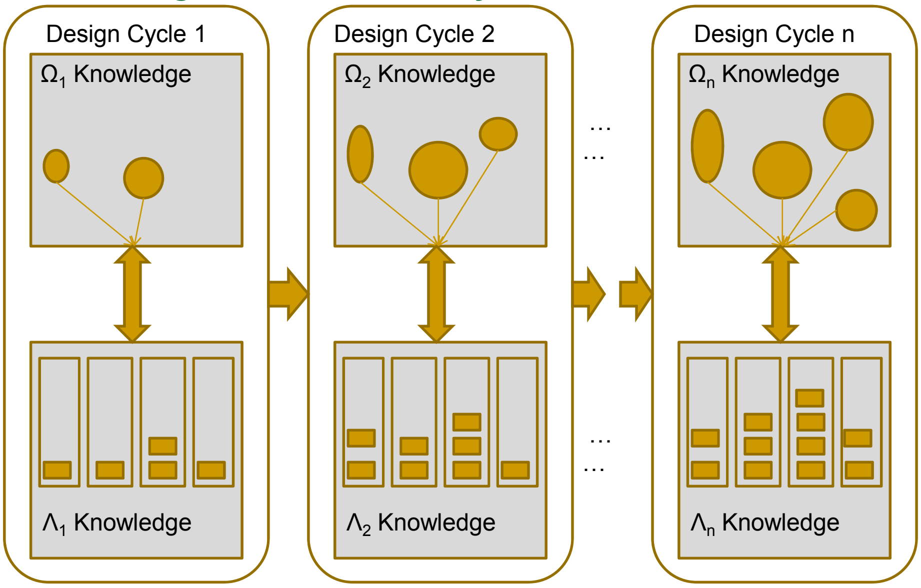
Levels of Artifact Abstraction

- Level 1 – Artifact as Situated Instantiation
  - Domain Specific problem solution
  - Specific Products and Processes
- Level 2 – Artifact Design Principles/Architecture
  - More General Knowledge for problem class
  - Models, Methods, Constructs, Partial Design Theory
- Level 3 – Emergent Design Theory
  - Fuller Design Theory (Never complete)
  - General Understanding leading to the development of Descriptive Theories of Artificial Phenomena Behaviors

The DSR Process

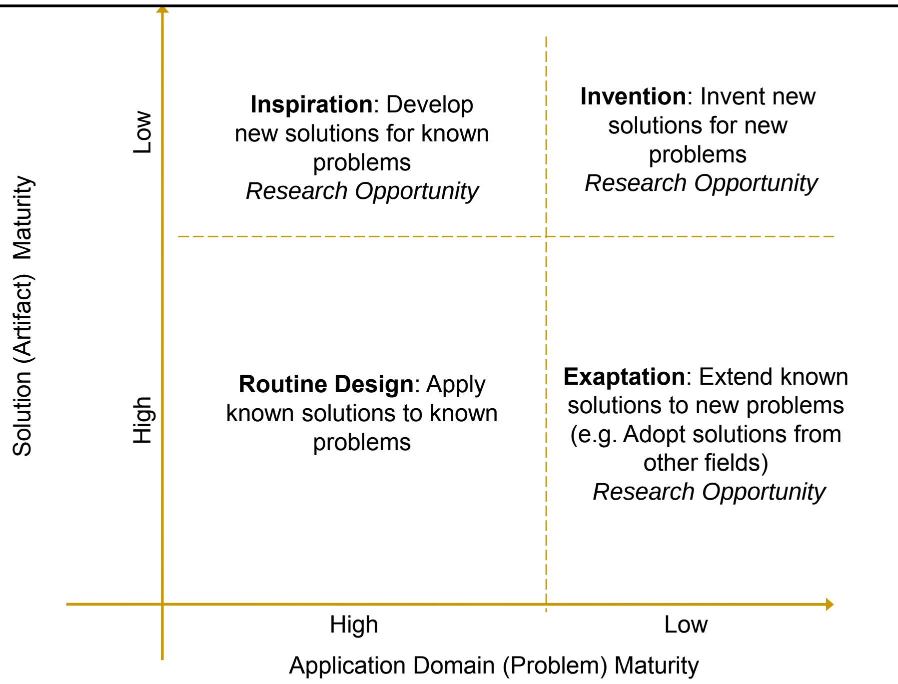


Knowledge Growth in DSR Cycles



DSR Knowledge Contribution Framework

- Two dimensions:
  - Maturity of Application Domain (Problems)
  - Maturity of Solutions (Existing Artifacts)
- Difficulties:
  - Subjectivity – where to draw the lines
  - Everything builds on something else, nothing entirely new



Invention Quadrant – Agrawal et al. (1993)

- Agrawal, R., Imielinski, T. and Swami, A. (1993). "Mining Association Rules between Sets of Items in Large Databases", *Proceedings of the 1993 ACM SIGMOD Conference*, Washington DC, May.
- Aim: produce an algorithm that generates all significant association rules between items in the database
- Practical importance: Allows organizations to find interesting relationships (e.g. shopping patterns)
- Theoretical significance (newness): Shows (Sect 5) that no other work has done same thing
- Description new method: Shows requirements (Sect 1), new concepts (association rule, support, confidence), Formal Model (pseudocode) (Sects 2-3)
- Proof: Experiments (Sect 4)

Inspiration Quadrant - Iversen et al. 2004

- Iversen, J., L. Mathiassen, and P. Nielsen (2004) "Managing Process Risk in Software Process Improvement: An Action Research Approach", *MIS Quarterly*, (28)3, pp. 395-434.
- Introduction
  - Aim – develop a risk management approach in s/w process improvement (SPI)
- Literature Review
  - Reviews literature on s/w process improvement, s/w risk management (known problems) including existing artifacts
  - Conclude – currently no comprehensive approach for managing risk in SPI
- Methodology
  - Action research (described at length) Research process
  - Describes 4 iterations
- Artifact description (termed research results)
  - Shows strategies for managing risks in SPI teams
- Discussion
  - Discusses action research process
  - Claims contribution to theory – advancement of state-of-the-art in SPI

Exaptation Quadrant – Adipat et al. 2011 MISQ

- Exapting effective web page presentation techniques to mobile devices
- Rigorous kernel theories from fit theory and information foraging theory
- Artifact – Presentation method
  - Hybrid of tree-view, hierarchical text summarization, and colored keyword highlighting
- Evaluation via prototype system
  - Experimental design – Search tasks of varying complexity performed on five variations of hybrid presentations
  - 60 university students
  - Dependent variables
    - Accuracy of search and time on task - measured
    - Ease of use and usefulness – perception survey
- Research contributions
  - Artifact improves effectiveness of web browsing on mobile devices
  - Impact of task complexity on presentation exaptation
  - Extends theories to mobile applications

Routine Design Quadrant

- Usually not publishable in good academic journals
- However, evolving or best practice may be observed and documented in "extractive case study" work (Van Aken)
- Example – Davenport's observation of BPR (Davenport & Short SMR 1990)

DSR Publication Schemata

Ch 1 – Introduction
- Problem definition, aims, research question, scope, relevance

Ch 2 – Literature review
- What others have done before (existing artifacts)
- Pointers to justificatory Kernel Theory
- Position research in Knowledge Contribution Framework

Ch 3 – Method (often omitted)
- Design Science Method
  - Principles of Implementation
  - Principles of Evaluation

Ch 4 – Description of the new artifact
- At least - Artifact description & development process
- Partial design theory
  - Purpose/requirements
  - Constructs/components
  - Principles of form and function/architecture
  - System mutability issues
  - Testable propositions

DSR Publication Schemata (cont.)

Ch 5 – Evaluation
- Experimental design and Evaluation process
- Summative test results

Ch 6 – Discussion and Conclusions
- Research Contributions (Summary of what has been learned)
  - Contributions to Prescriptive Knowledge
  - Contributions to Descriptive Knowledge
- Claims for novelty and significance
- Highlight important findings (declaration of victory)

DSR Guidelines in Chapters

Guideline	Chapter Presentation
Guideline 1: Design as an Artifact	Chapter 1 – Motivate need for artifact to solve problem Chapter 4 – Full description of artifact
Guideline 2: Problem Relevance	Chapter 1 – Motivation to include clear statement of problem relevance Chapter 6 – Full discussion of impacts to research and practice
Guideline 3: Design Evaluation	Chapter 3 – Principles of Evaluation Chapter 5 – Full discussion of artifact evaluation to include research results
Guideline 4: Research Contributions	Chapter 2 – Positioning of research in contribution framework Chapter 6 – Full discussion of research contributions
Guideline 5: Research Rigor	Chapter 2 – Appropriate and complete literature review Chapter 3 – Design methods based on implementation and evaluation principles Chapter 4 – Rigorous development of artifact Chapter 5 – Rigorous evaluation of artifact
Guideline 6: Design as a Search Process	Chapter 3 – Principles of Implementation Chapter 4 – Full discussion of artifact development
Guideline 7: Communication of Research	All chapters

Publishing Design Research

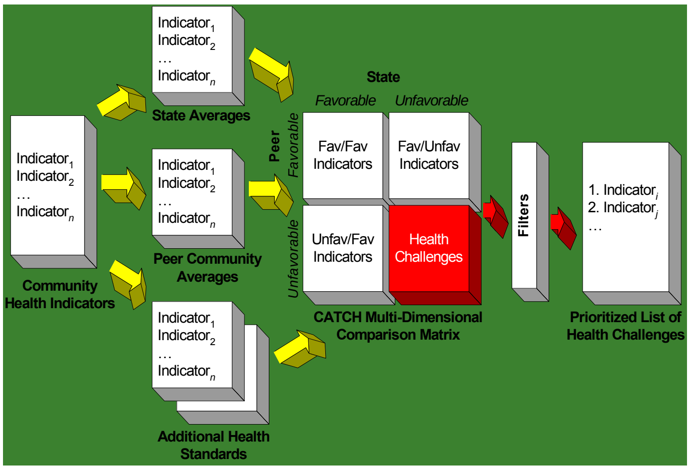
- Competitive Workshops and Conferences
  - Present ideas and receive feedback from reviews and live questions, Refine ideas
  - ACM, IEEE, AIS, INFORMS, AMIA Conferences
  - Opportunities to Fast-Track to Journals
- Journal Submission
  - Know the Audience of the Journal (Technical, Managerial) and Focus Research Contributions
    - Read relevant papers from Journal and Cite them
  - Contact Senior Editors for guidance
  - Aim High and Be Persistent

Design Research Exemplars

- CATCH Health Data Warehouse
  - D. Berndt, A. Hevner, and J. Studnicki, “The CATCH Data Warehouse: Support for Community Health Care Decision Making,” *Decision Support Systems*, Vol. 35, June 2003, pp. 367-384.
  - D. Berndt, J. Fisher, A. Hevner, and J. Studnicki, “Healthcare Data Warehousing and Quality Assurance,” *IEEE Computer*, Vol. 34, No. 12, December 2001, pp. 33-42.
  - J. Studnicki, A. Hevner, D. Berndt, and S. Luther, “Rating the Health Status of U.S. Communities,” *Managed Care Interface*, Vol. 14, No. 11, November 2001, pp. 43-51.
  - J. Studnicki, A. Hevner, D. Berndt, and S. Luther, “Comparing Alternative Methods for Composing Community Peer Groups: A Data Warehouse Application," *Journal of Public Health Management and Practice*, Vol. 7, No. 6, November 2001, pp. 87-94.
  - D. Berndt, A. Hevner, and J. Studnicki, “Data Warehouse Dissemination Strategies for Community Health Assessments,” *Informatik/Informatique*, Journal of the Swiss Informatics Society, No. 1, February 2001, pp. 27-33.
  - J. Studnicki, B. Steverson, B. Myers, A. Hevner, and D. Berndt, “Comprehensive Assessment for Tracking Community Health (CATCH),” *Best Practices and Benchmarking in Healthcare*, Vol. 2, No. 5, September/October 1997, pp. 196-207.
- Data Quality in Health Systems for Decision-Making
  - M. Trembley, *Uncertainty in the Information Supply Chain: Integrating Multiple Health Care Data Sources*, Ph.D. Dissertation, IS/DS, Univ. of South Florida, Tampa, July 2007.
  - M. Tremblay, R. Fuller, D. Berndt, J. Studnicki, “Doing more with more information: Changing healthcare planning with OLAP tools,” *Decision Support Systems*, Vol. 43, No. 4, August 2007, Pages 1305-1320.
  - M. Tremblay, A. Hevner, and D. Berndt, “Focus Groups for Artifact Refinement and Evaluation in Design Research,” *Communications of the Association for Information Systems*, Vol. 26, Article 27, June 2010, pp. 599-618.
  - Multiple papers under review at journals

CATCH Methodology

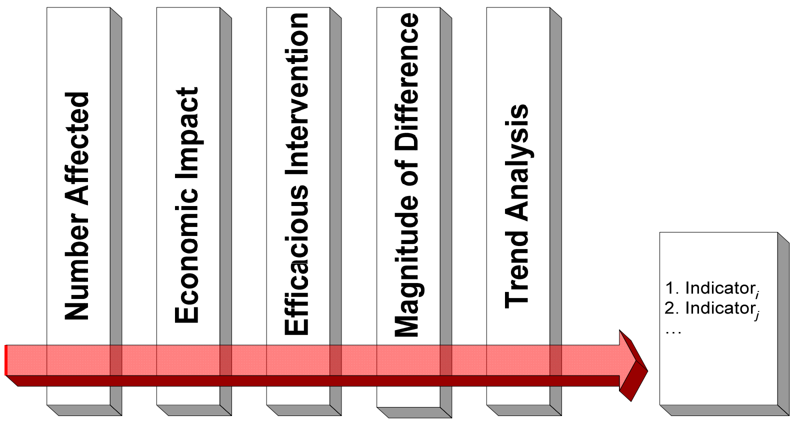
- Comprehensive Assessment for Tracking Community Health (CATCH)
- More than 30 Florida County Applications



Data Collection and Analysis

- Ten Indicator Groups
  - Demographics
  - Socioeconomic
  - Maternal and Child Health
  - Social and Mental Health
  - Physical Environmental Health
  - Health Status: Morbidity/Mortality
  - Sentinel Events
  - Infectious Diseases
  - Health Resource Availability
  - Behavioral Risk Factors

Priority Filters

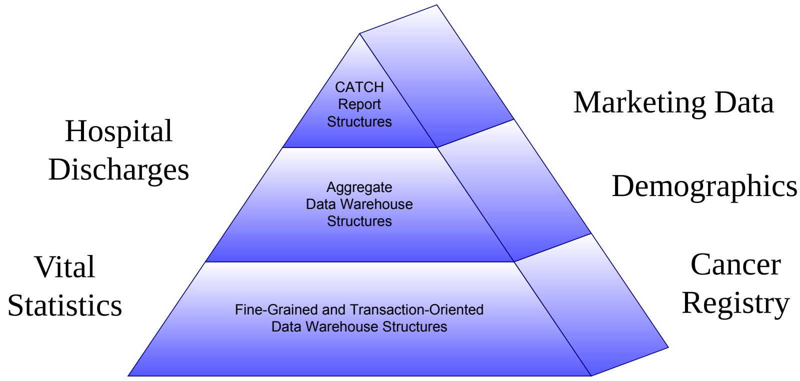


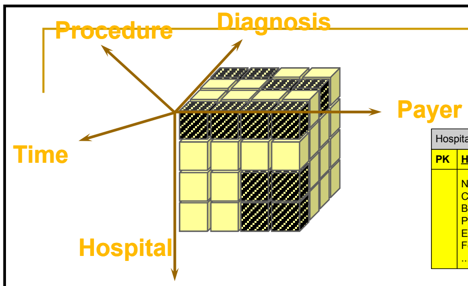
Data Warehouse Design Challenges

- Data Warehouse Design
- Initial Data Collection and Loading
- Ongoing Data Staging and Quality Assurance
- Performance and Tuning
- Security and Recovery
- User Interfaces / Data Dissemination
- Knowledge Discovery and Data Mining

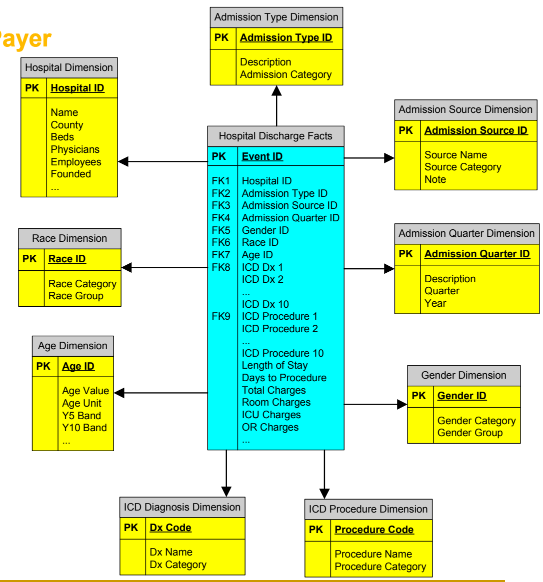
CATCH Data Warehouse

- Utilizes over 300 health status indicators.





Hospital Discharge Star Schema

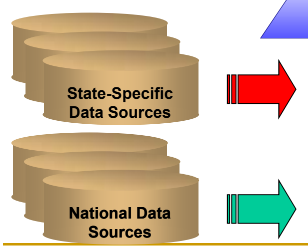


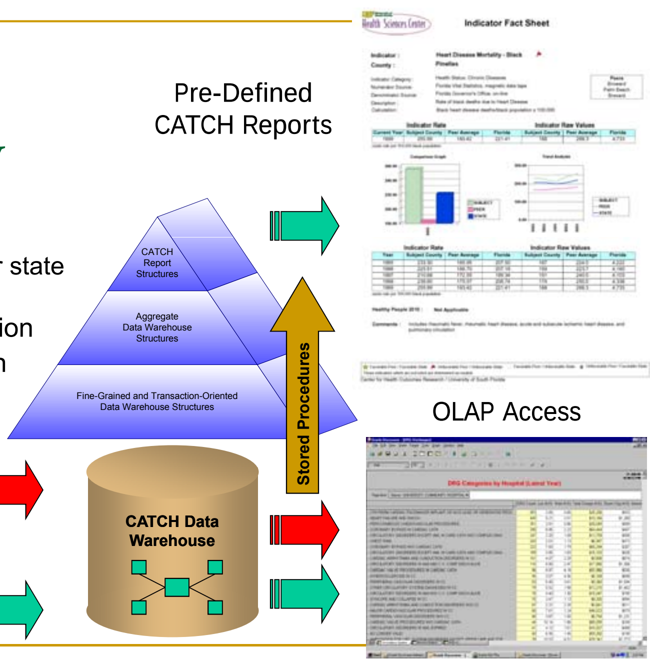
Data Dissemination Modes

- Effective Presentation of Data Warehouse Information to Decision Makers
- Data Dissemination Modes
  - Ad-Hoc Queries and Data Browsing (SQL/QBE)
  - Pre-Defined Report Generation
  - Desktop Data Warehousing (MS Excel)
  - Online Analytic Processing (OLAP)
  - Geographic Information Systems (GIS)
  - Web-Enabled Access

CATCH Workflow

- Data Staging
  - Customized for state data.
- Indicator Calculation
- Report Production





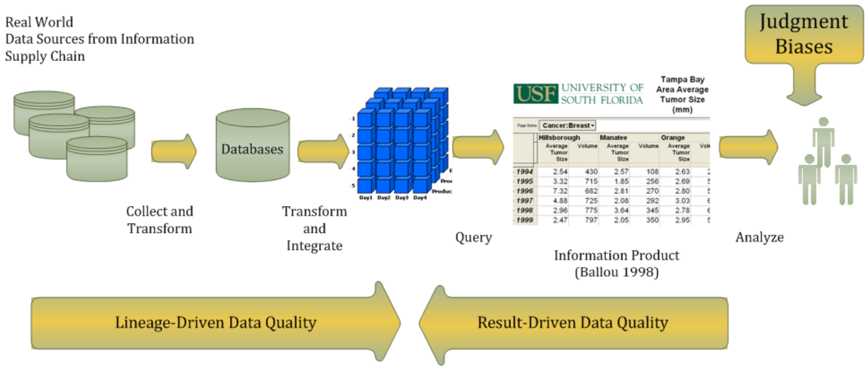
CATCH Research Directions

- Physician/Hospital/Procedure Volume and Patient Safety Outcomes
- Analysis of Health Disparities
- Bioterrorism Surveillance Systems
- Environmental Health Impacts – EPA Project

Managing Data Uncertainty in the Health Information Supply Chain

- Research Context:
  - Public policy knowledge workers in health
  - OLAP tools draw data from multiple data sources in a health care information supply chain
  - Data quality challenges
    - Data are unbounded
    - Data definitions and schemas vary
    - No guarantees of data quality
  - Knowledge workers make 'gut instinct' decisions with available data of unknown quality
    - Judgment biases are prevalent

Research Landscape



Research Questions

RQ1	Design result-driven data quality metrics that will aid decision-makers in the analysis of data from multiple data sources with varying levels of data quality in the health care information supply chain.
RQ2	What is the utility of the data quality metrics?
RQ3	What is the efficacy of the data quality metrics in altering a decision maker's data analytic strategies?

Data Quality Measurements

Data Quality Problem (Wang and Strong 1996)	Metric
Completeness. Missing codes or has codes that do not match other sources of data result in data that are not assigned to any of the possible cells in a data cube.	Unallocated data metric
Representational Consistency. When considering aggregated data or when observing trends decision makers rely on point estimates, such as an average, which may be biased by noisy data.	Information volatility metric intra-cell and inter-cell
Appropriate Amount of Data. Insensitivity to sample size by decision makers when considering/comparing groupings	Sample size metric

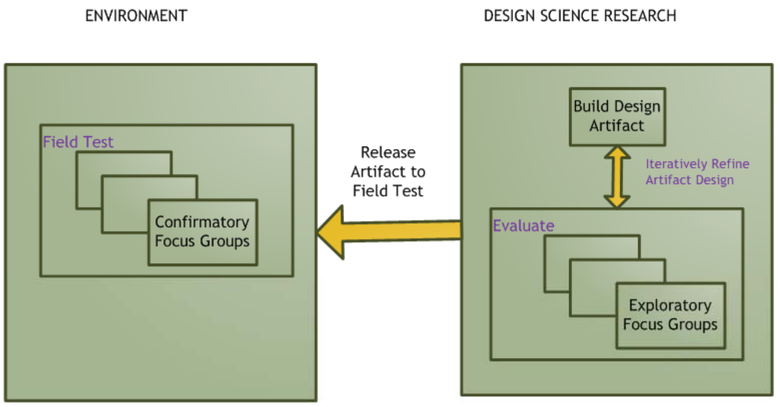
Research Artifacts

- The Artifacts are:
  - Data Quality Metrics on Data Products
  - New Algorithms for Calculating Data Quality Metrics on Data Products
  - New Methods for Comparing and Integrating Data Products
  - New Human-Computer Interface Presentations to support Decision-Making

Research Rigor

- Design Constructions grounded by:
  - Data Products Foundations [Shankaranarayan et al. 2003]
  - Data Quality Foundations [Wang et al. 1997]
  - Behavioral Decision-Making Foundations [Tversky and Kahneman 1982]
- Design Evaluations grounded by:
  - Field Study of Public Health Decision-Makers
  - Focus Groups of Experts

Evaluation: Exploratory and Confirmatory Focus Groups



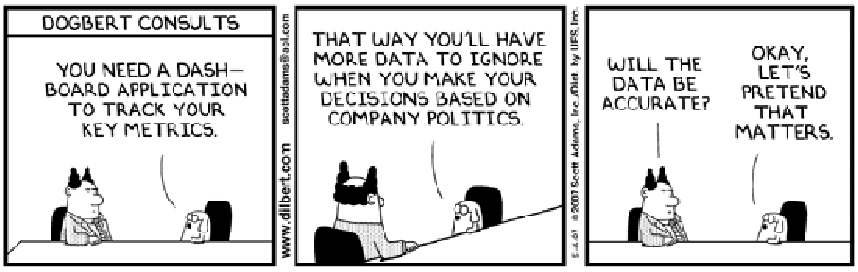
Evaluation Vignettes in Focus Groups

Metric Evaluated	Vignette	Decision
Unallocated data metric	Studies have shown that smoking is responsible for most cancers of the larynx, oral cavity and pharynx, esophagus, and bladder.	Is there correlation between smoking and certain types of cancer?
Unallocated data metric	When Hispanics are diagnosed with a certain cancer (fictitious example), they're less likely to receive chemotherapy than non Hispanics.	Is there disparity in care between ethnic groups?
Information volatility metric	Counties neighboring the target county are better at early detection/prevention of Breast Cancer based on volumes of cases.	Examine trend – is this a true claim?
Sample size metric	Tumor size has been shown to be a good predictor of survival for certain cancers, including: breast, lung and endocrine. Compare average tumor size in the target county to that of neighboring counties.	How does the target county compare to other counties?

Research Impacts

- Research Questions driven by Real-World Challenges
- Research Artifacts (Data Quality Metrics in an Information Supply Chain) are being used in to make Health decisions in real environments
- Evaluation performed via Focus Groups
  - Exploratory FGs to improve artifact design
  - Confirmatory FGs to evaluate utility and efficacy in Field Setting
- On-Going R&D to integrate Metrics into Health Decision Making Tools and Processes

Reality Check from Dogbert



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Design Science Issues

- Not Reinventing the Wheel – Drawing and Learning appropriately from disciplines with long histories of design research
- Producing Top-Quality Design Research
  - Gaining Credibility within IS and among other design disciplines
  - MISQ and other top IS journals will publish design research if it is 'good research'
- Building a comprehensive Knowledge Base of Design Theory and Practice
  - Insufficient Sets of Constructs, Models, Methods, and Tools in Knowledge Base to Represent real-world Problems and Solutions
- Understanding the role of Rigor in Design Research
  - Design is still a Craft relying often on Creativity, Intuition, Experience, and Trial-and-Error
  - Design Research vs. Routine Design
- Design Research is perishable as technology advances rapidly
  - Greater focus on conferences in design disciplines
- Communication of Design Research Results to Managers is Essential but a Major Challenge
  - Separate publications for technical and management audiences

Questions and Discussion

Design as an Artifact

- The IT Artifact is the 'core subject matter' of the IS field.
- Artifacts are innovations that define the ideas, practices, technical capabilities, and products through which the analysis, design, implementation, and use of IS can be accomplished.
- Design Science Research in IS must produce an Artifact
  - Construct, Model, Method, Instantiation
- Research Design vs. Routine Design
  - Innovation vs. Use of Known Techniques

Problem Relevance

- Research Motivation
- The Problem must be real and interesting.
- Problem solving is a search process using actions to reduce or eliminate the differences between the current state and a goal state [Simon 1999].
- Design Science Artifact must be relevant and useful to IS practitioners - Utility.

Design Evaluation

- Rigorous Evaluation of the Utility, Quality, and Beauty (i.e., Style) of the Design Artifact.
- Evaluation provides feedback to the Construction phase for improving the artifact.
- Design Evaluation Methods

Design Evaluation Methods

1. Observational	Case Study – Study artifact in depth in business environment
	Field Study – Monitor use of artifact in multiple projects
2. Analytical	Static Analysis – Examine structure of artifact for static qualities (e.g., complexity)
	Architecture Analysis – Study fit of artifact into technical IS architecture
	Optimization – Demonstrate inherent optimal properties of artifact or provide optimality bounds on artifact behavior
	Dynamic Analysis – Study artifact in use for dynamic qualities (e.g., performance)
3. Experimental	Controlled Experiment – Study artifact in controlled environment for qualities (e.g., usability)
	Simulation – Execute artifact with artificial data
4. Testing	Functional (Black Box) Testing – Execute artifact interfaces to discover failures and identify defects
	Structural (White Box) Testing – Perform coverage testing of some metric (e.g., execution paths) in the artifact implementation
5. Descriptive	Informed Argument – Use information from the knowledge base (e.g., relevant research) to build a convincing argument for the artifact's utility
	Scenarios – Construct detailed scenarios around the artifact to demonstrate its utility

Research Contributions

- What is New and Interesting?
- Does the Research make a clear contribution to the business environment, addressing a relevant problem?
- The Design Artifact
  - Exercising the artifact in the problem domain adds value to the IS practice
- Foundations
  - Extend and improve foundations in the design science knowledge base
- Methodologies
  - Creative development and use of methods and metrics

Research Rigor

- Use of Rigorous Research techniques in both the Build and Evaluate phases
- Building an Artifact relies on mathematical foundations to describe the specified and constructed artifact.
  - Principles of Abstraction and Hierarchical Decomposition to deal with Complexity
- Evaluating an Artifact requires effective use of techniques in previous slide.
- Research must be both Relevant and Rigorous

Design as a Search Process

- Good design is based on iterative, heuristic search strategies.
  - Simon's Generate/Test Cycle
  - Problem Simplification and Decomposition
  - Modeling Means, Ends, and Laws of the Problem Environment
- The Search for Optimal Solutions may not be feasible or tractable.
- The Search for Satisfactory Solutions may be the best we can do - Satisficing

Communication of Research

- Technical audiences need sufficient detail to construct and effectively use the artifact.
  - How do I build and use the artifact to solve the problem?
- Managerial audiences need an understanding of the importance of the problem and the novelty and utility of the artifact.
  - Should I commit the resources (staff, budget, facilities) to adopt the artifact as a solution to the problem?
- Research presentation must be fitted to the appropriate audience (e.g., journal).