THE FRONT END OF INNOVATION: IMPLICATIONS FOR DESIGN AND LEARNING

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Outline

1. Introduction

   The Front End of Innovation (FEI)
2. Grounding Perspectives
3. Knowledge Innovation Matrix (KIM)
4. FEI-KIM Model
5. Assessing the FEI-KIM Model
6. Building Design Theory for FEI
7. Discussion

1. Introduction

“Our department is continually being told to be innovative, but no one tells us how to do it. They don’t say what they mean by innovation, or what they want to achieve!”

- CIO of large Australian Government Agency, 2014.

- “It’s time to dispel the myth that innovation only happens outside the classroom and use that knowledge to create more collaborative innovation between educators and edtech entrepreneurs.”
  - Molly Levitt, Founder of BrightLoop, 2014

What is an Innovation?

- An idea, practice or object that is perceived as new by an individual or other unit of adoption (Rogers 2003)
- Innovation is about knowledge – creating new possibilities through combining different knowledge sets (Tidd and Besant 2009)
- Practical, useful creativity (innovation) involves devices or systems that perform tasks or solve problems (Horenstein 2002)

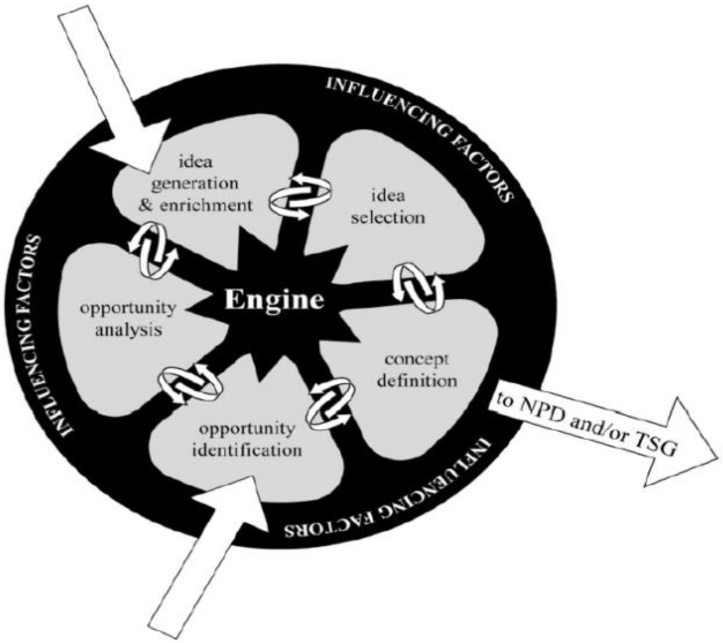
Why Innovation?

- Innovation drives economic growth and societal gains (Schumpeter, 1942)
- Competitive necessity for organizations
- Innovations include products, services, business processes, modes of educational delivery, and business models
- Despite huge innovation literature, innovation processes are haphazard and need more attention
- While innovation is desired, innovation processes are given little attention in learning environments

Innovation Issues

- Conflicting advice to managers
- Plethora of terms & categorizations (radical vs incremental, exploration vs exploitation, ambidexterity)
- Wide range of practices (design thinking, means-end analysis, genius grants, crowdsourcing, open innovation, brain storming, road mapping)
- Resistance to change (e.g. managers with habitual mindsets)
- No sound theory-based classification system and typological theory

Research Objectives



From Koen et al. 2001, "Providing Clarity and a Common Language to the Fuzzy Front End."

- Develop a typological Front End Innovation theory
- Show how different patterns of practice are required for different types of innovation
- Show organizations how to be "multi-dexterous"

  (Multi-dexterity = range of innovation project types)

  – Develop a mapping tool to assess level of multi-dexterity
  – Suggest areas/methods to increase multi-dexterity

2. Grounding Perspectives

2.1 Innovation

2.2 Creativity

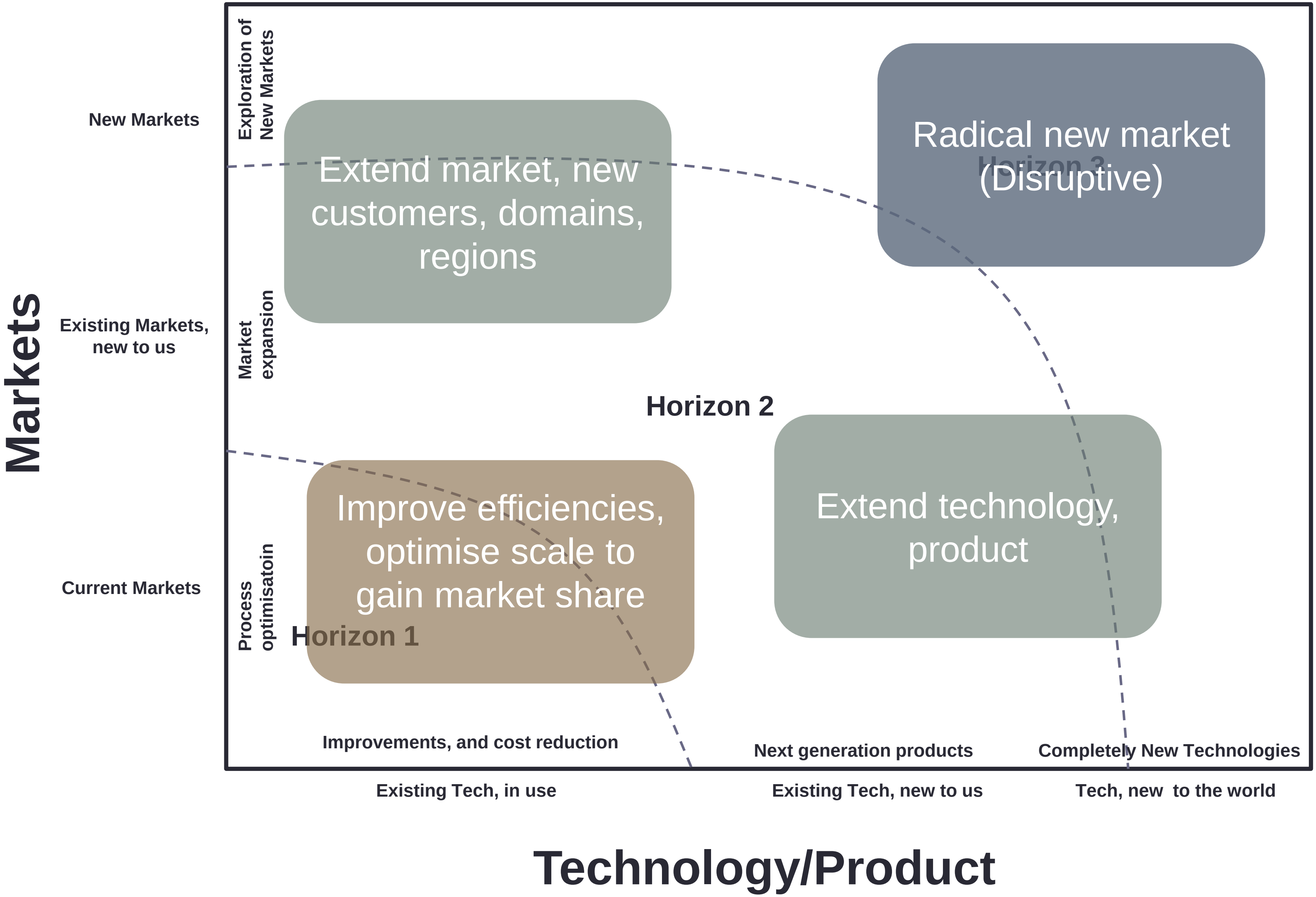
2.3 Knowledge

2.4 Design Science

2.1 Innovation

- Huge literature to explore
- The Innovation Journey (Van de Ven et al. 2008)
- New Concept Development (NCD) (Koen et al. 2014)
- Design-Based Research in Education (Anderson & Shattuck 2012)
- IT as a general-purpose disruptive technology (David 1990)
- Gartner’s hype cycle (Linden & Fenn 2003)
- Three-horizon model (McKinsey)

McKinsey Innovation Horizons



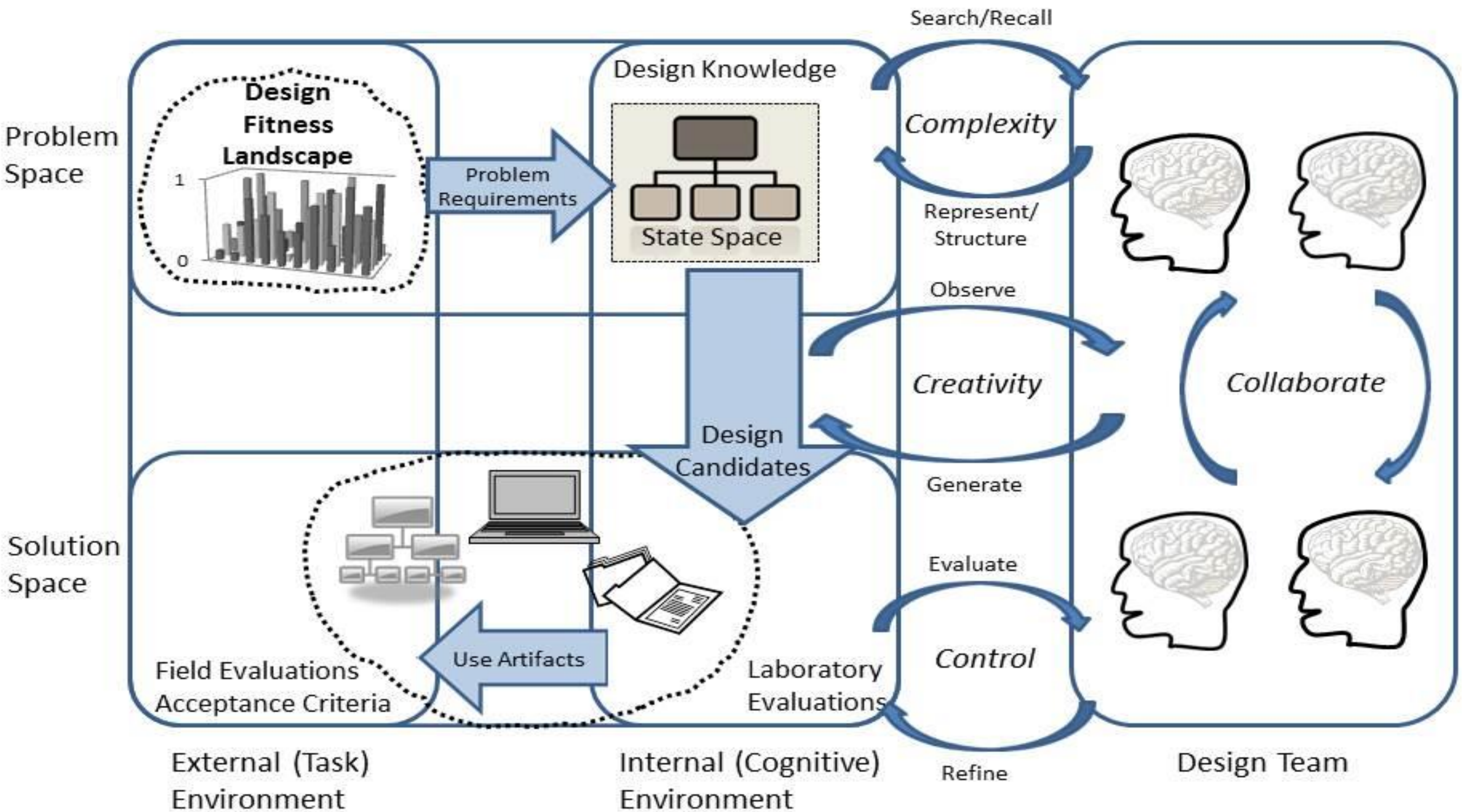
Categorizations of Innovation

- Ansoff matrix – used for strategizing (Ansoff 1957)
- Exploration versus exploitation (March 1991; Levinthal & March 1993)
- Surveys of innovation categorization schemes (Garcia & Calantone 2002; Miller & Miller 2012)
- None are result of careful theory-based analysis

2.2 Creativity

- Creativity underpins innovation
- Amabile's componential model of creativity (Amabile 1996; 2012)
  - Domain-relevant skills (expertise/knowledge)
  - Creativity-related processes (individual level)
  - Task motivation (intrinsic)
  - Surrounding social environment
- Neuroscience model of creativity
  - Mapping of brain regions during creative activities
  - A neuroscience model of creative processes is an attempt to unify conflicting psychological perspectives on creativity: is it a "mysterious result of spontaneous irrational processes" or a "planned, deliberate result of methodological problem solving" or an amalgam of both?

NeuroDesign Model of Innovation



From: A. Hevner, C. Davis, R.W. Collins, and T.G. Gill, “A NeuroDesign Model for IS Research,” *Informing Science: The International Journal of an Emerging Transdiscipline*, 17, 2014, pp. 103-132.

Cognitive Interactions in Innovation

- Structure Problem – What cognitive activities address the complexities of the problem space? How does the brain search the problem statement for potential solution patterns while finding effective representations of problem structure?
- Produce Novelty – How does the brain create new ideas for the production of innovative design candidates?
- Manage Refinement – How does the brain control the assessment of candidate designs and search for the 'best' designs to instantiate as use artifacts?
- Achieve Consensus – How do humans collaborate with others on the design team and with design stakeholders throughout the design process?

2.3 Knowledge

- Innovation is about knowledge – creating new possibilities through combining new knowledge sets (Tidd and Bessant 2009)
- Innovation supports the growth of Knowledge & Knowledge Flows (Mokyr 2002)
- The Knowledge-Creating Company (Nonaka 1991, Nonaka et al. 2008)

Useful Knowledge

Ω – Descriptive Knowledge

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

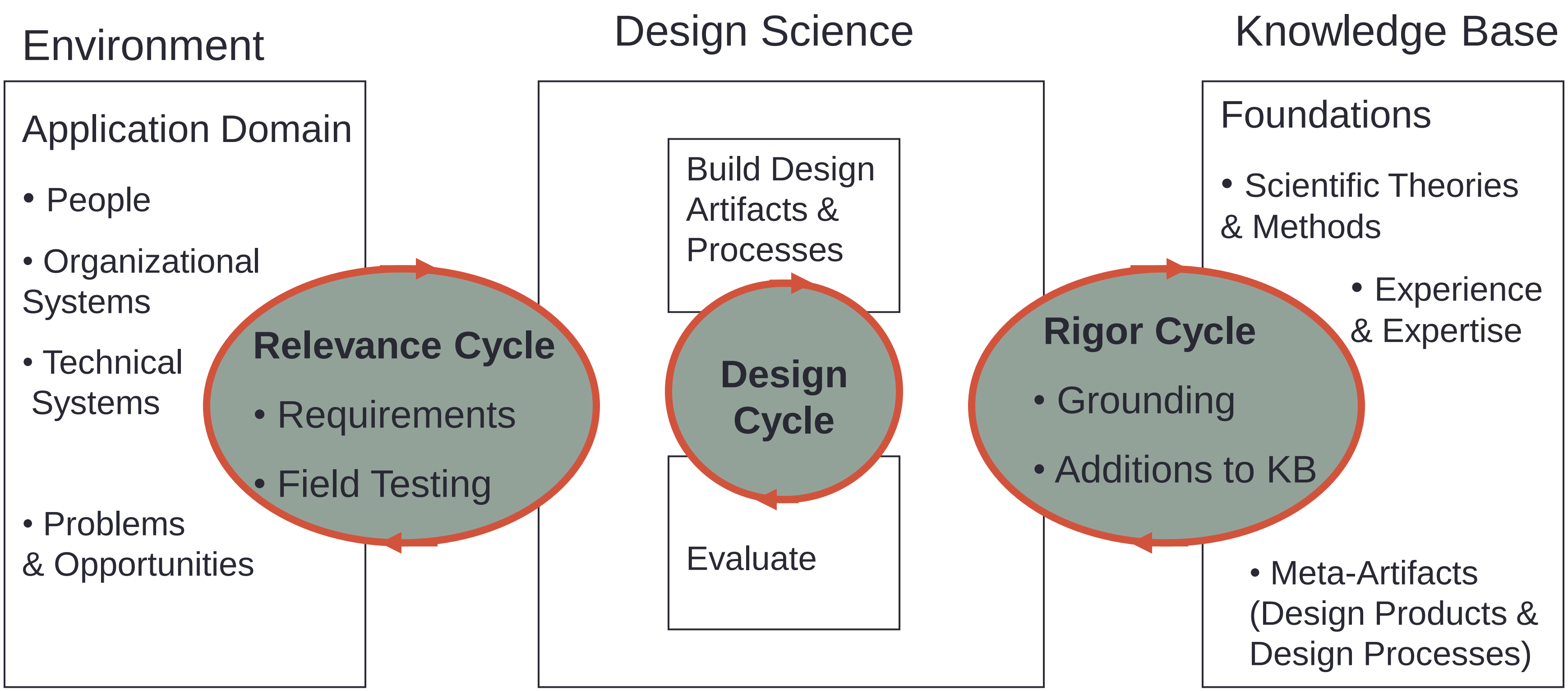
Λ – Prescriptive Knowledge

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

2.4 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 Many Fields – Long Histories
  - Engineering, Education, Architecture, Art
  - Role of Creativity in Design
- DSR in Information Systems
  - 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.

Three Cycles of DSR



From: A. Hevner, "A Three Cycle View of Design Science Research," *Scandinavian Journal of Information Systems*, Vol. 19, No. 2, 2007, pp. 87-92.

Design Research Guidelines

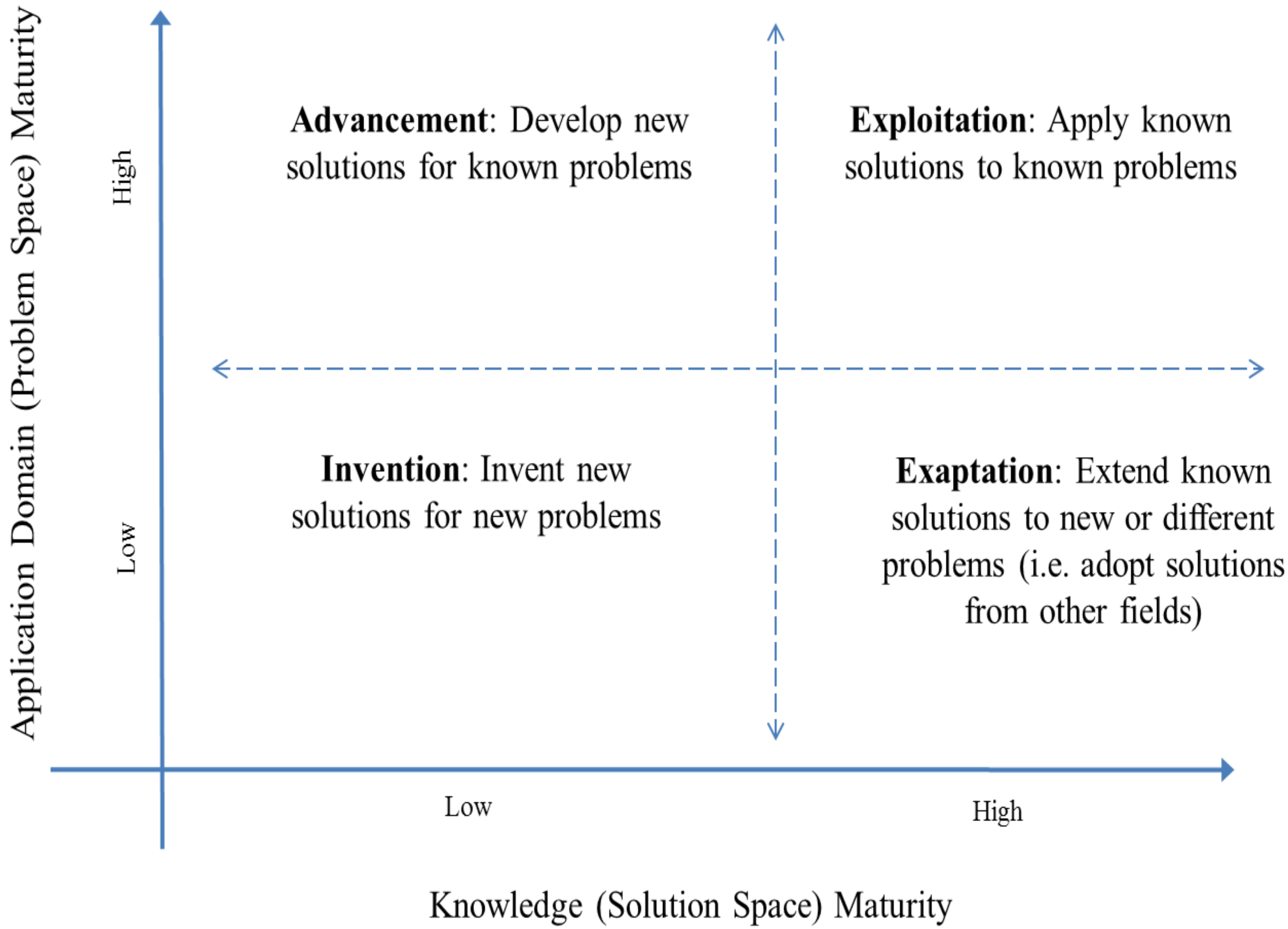
Guideline	Description
Guideline 1: Design as an Artifact	Design-science research must produce a viable artifact in the form of a construct, a model, a method, or an instantiation.
Guideline 2: Problem Relevance	The objective of design-science research is to develop technology-based solutions to important 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.

The Artifact as Knowledge

	Contribution type	**Examples**
More abstract, complete, and mature knowledge	Level 3. Well-developed design theory about embedded phenomena	Design theories (mid-range and grand theories)
↕ ↕ ↕ ↕	Level 2. Nascent design theory – knowledge as operational principles/architecture	Constructs, methods, models, design principles, technological rules.
More specific, limited, and less mature knowledge	Level 1. Situated implementation of artifact	Instantiations (software products or implemented methods)

3. Knowledge Innovation Matrix (KIM)

- Two fundamental dimensions of innovation:
  - Knowledge maturity
    - (Knowledge = idea, solution)
  - Application need maturity
    - (Need = goal, purpose, problem, task, function, application, use, market)
- Gives 2x2 matrix, 4 quadrants

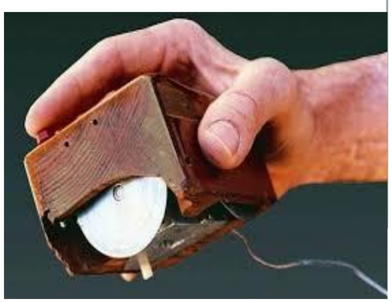


Adapted from: Gregor & Hevner (2013, 2014)

Exemplars

Advancement -
Improved knowledge for recognized need

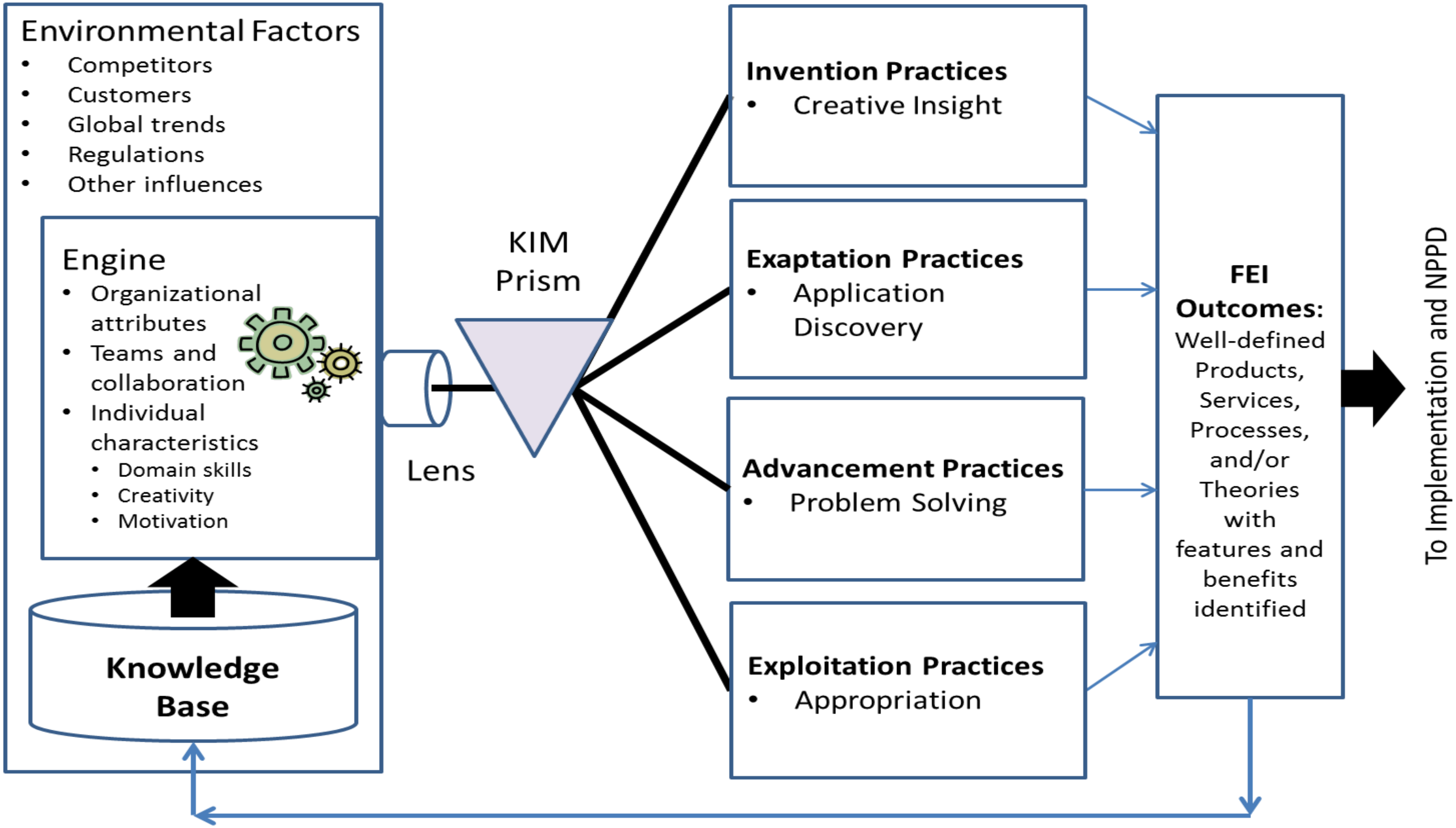
Exploitation –
Apply existing knowledge to recognized need (new-to-us)



Invention -
New knowledge for unrecognized need (new-to-world)

Exaptation -
Apply existing knowledge to different need (re-purpose)

4. The FEI-KIM Model



The KIM Prism

- Identifies and Distinguishes the four types of Innovation
- Different practice patterns of effective FEI activities will depend on the type of innovation being explored – invention, exaptation, advancement, or exploitation.
- The KIM-FEI model posits that effectiveness and eventual success in each innovation category will require variations in innovation activities, organizational environment, team skills, and produced outcomes.

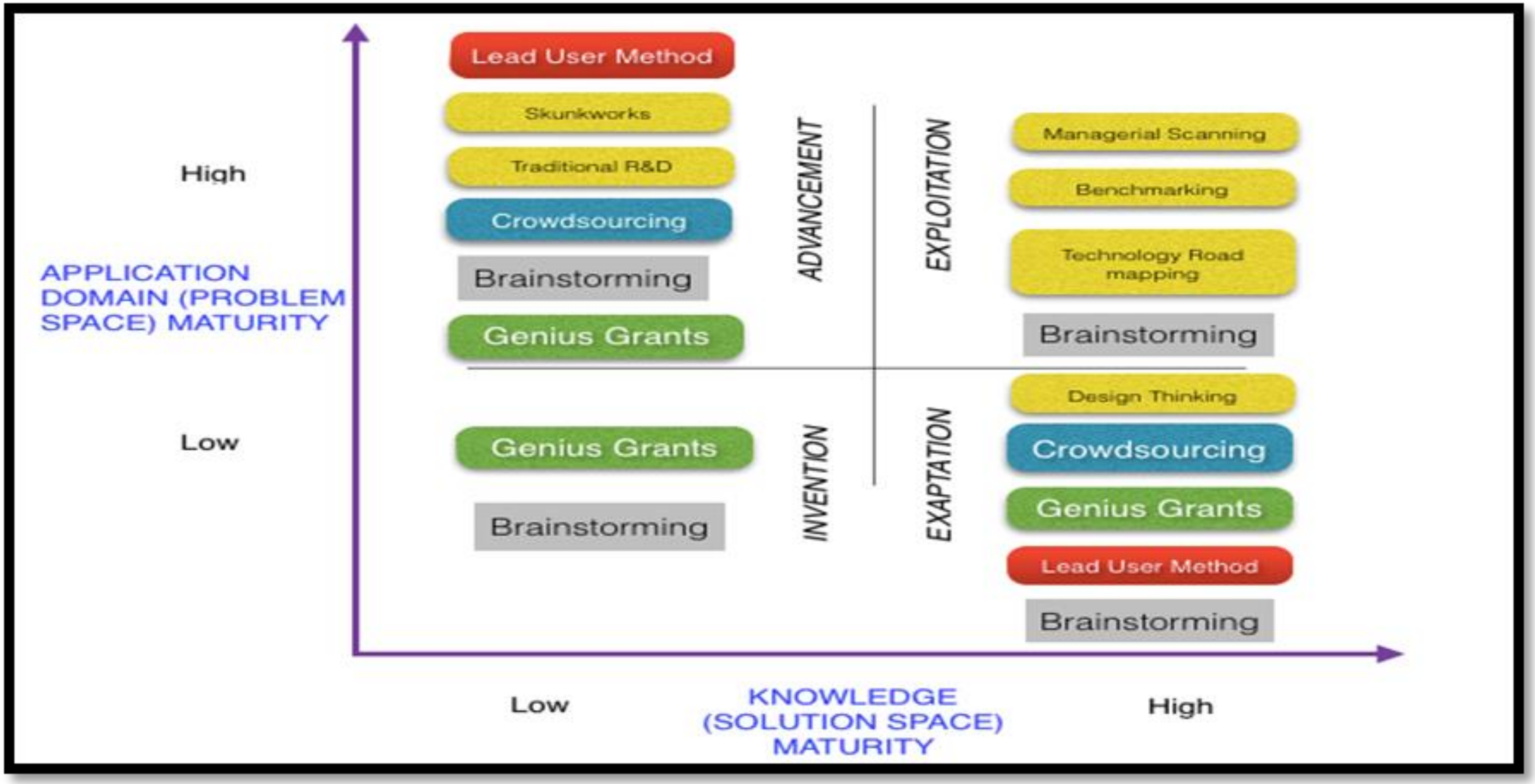
5. Assessing the FEI-KIM Model

- Chadha, Y., Mehra, A., Gregor, S. and Richardson, A. (2015). A Framework for Techniques for Information Technology Enabled Innovation, *Australasian Conference on Information Systems*, Adelaide, December 2015.
- Exploratory study to map eleven commonly used innovation techniques into one or more of the innovation quadrants
- Innovation managers at nine Australian IT companies were surveyed on the use of these techniques for organizational innovation

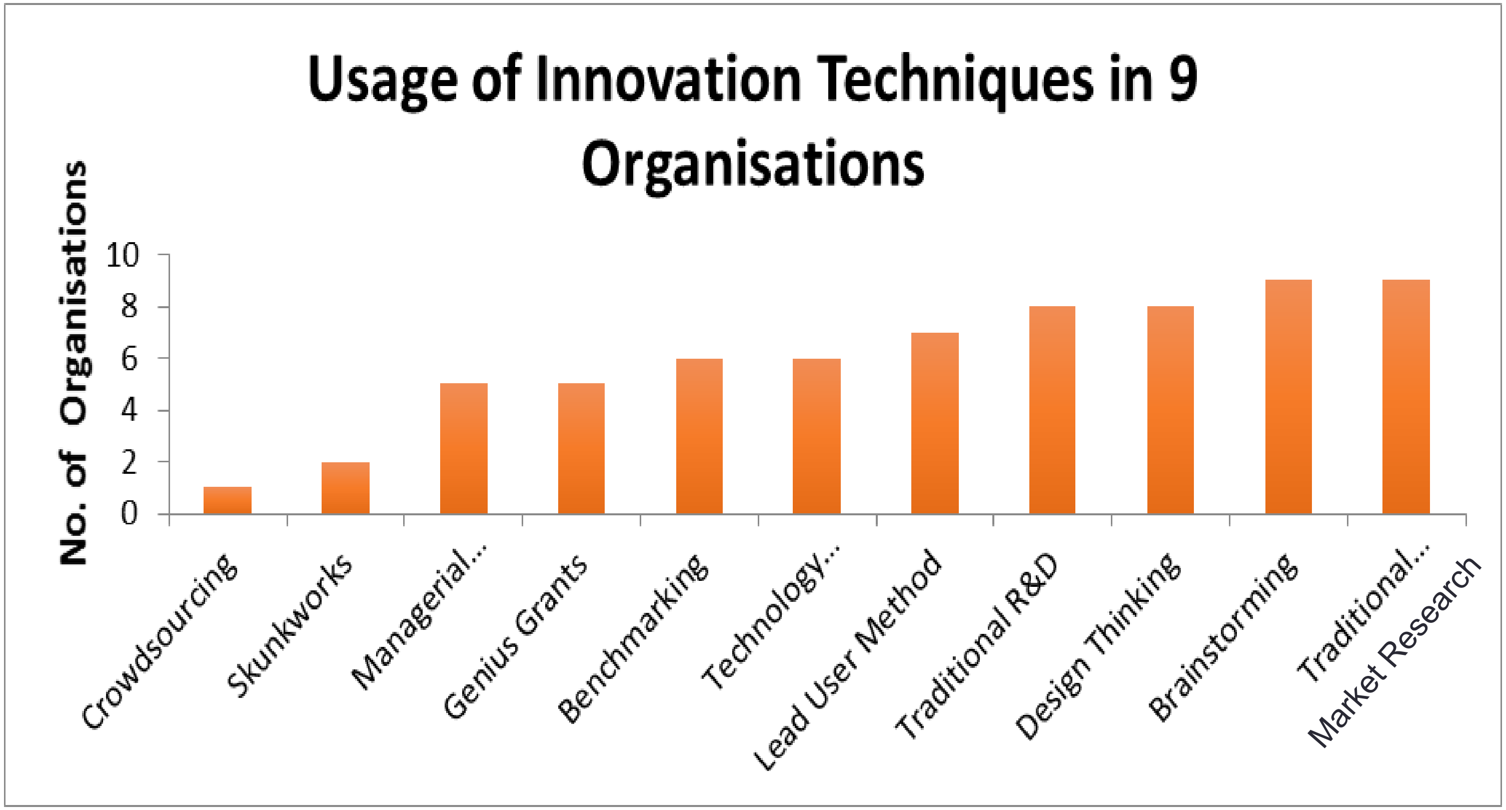
Innovation Techniques

- Lead user method
- Skunk works
- Genius grants
- Design thinking
- Benchmarking
- Managerial scanning
- Crowdsourcing
- Research and development
- Traditional market research
- Brainstorming
- Technology road mapping

KIM Mapping of Innovation Techniques



Use of Techniques in Industry



6. Building Design Theory

- The KIM-FEI model provides the basis for the development of a nascent design theory for the FEI
- Within each innovation type, we propose a set of Research Propositions that focus on the unique characteristics of that innovation type project

Invention Propositions

- Organizational attributes that foster creativity, including policies that give freedom to employees to investigate problems of their own devising in free time, allowing innovators to incubate ideas (e.g. bootlegging policies);
- Supportive teams with colleagues who encourage original thinking and tolerate eccentricities.
- Individual characteristics that typify highly creative people, including strong intrinsic motivation. However the innovators may be fringe experts in so far as the innovation is concerned.
- Activities as in the creative process: preparation, incubation, evaluation and elaboration (genius grants etc).

Exaptation Propositions

- Organizational attributes that include resources to encourage contributions of diverse ideas and connections between these ideas, for example open innovation through crowdsourcing.
- Collaborative teams with diversities in domain expertise and technical skill sets.
- Individual characteristics that typify highly creative people, including strong intrinsic motivation in many cases. However the innovators may be fringe experts in so far as the innovation is concerned.
- Activities termed application discovery, where individuals, teams or groups are encouraged to generate ideas for re-purposing existing knowledge (e,g. brainstorming, ideation exercises).

Advancement Propositions

- Environmental factors such as access to important knowledge sources in the knowledge base, including the latest scientific research. What advancement improvements will make a true difference in the current IT environment and how is that advancement measured?
- Organizational attributes that include an open, innovative culture that allows experimentation and risk taking.
- Research and development teams with collaborative, disciplined, and creative colleagues.
- Individual characteristics that typify creative people, including strong intrinsic motivation. The innovators will require true expertise to fully understand the current state of knowledge and envisage potential solutions that will make a difference.
- Activities as in problem solving, with heuristic search for a solution taking place in a problem space, with actions such as experiments (traditional R&D).

Exploitation Propositions

- Environmental factors such as market analysis, competitor threats, customer trends, and regulatory changes that supply an innovator with an opportunity that could lead to value-added advantages. A knowledge base is required from which the ideas behind the innovation can be retrieved and applied.
- Organizational attributes that include senior management vision and organizational strategy.
- Development teams that can apply cutting-edge technologies to interesting problems.
- Individual characteristics that typify creative people in a professional role with expertise in the restructuring and redefining of the innovation to fit a new context, e.g. software engineering or change management expertise.
- Activities as in the innovation appropriation process: agenda-setting, matching, redefining/restructuring, clarifying, and routinizing, benchmarking.

5. Discussion

- The FEI-KIM Model advances a new approach for viewing the front-end of innovation both from theory and practice.
- The KIM Prism identifies different activity patterns based on the type of innovation creating a typology of innovation
  - Creative Insight Patterns for Invention
  - Application Discovery Patterns for Exaptation
  - Problem Solving Patterns for Advancement
  - Appropriation Patterns for Exploitation

Future Research Directions

- Validation of FEI-KIM Model
  - Industry Field Studies and Surveys
- Implications for Government Funding of Basic and Applied Research
- Multi-Dextrous Innovation Portfolios
  - 2016 Project mapping innovation practices
  - Effective Mixes of Innovation Types for ROI
- Science Evolution and Technology Evolution
  - Innovation implications

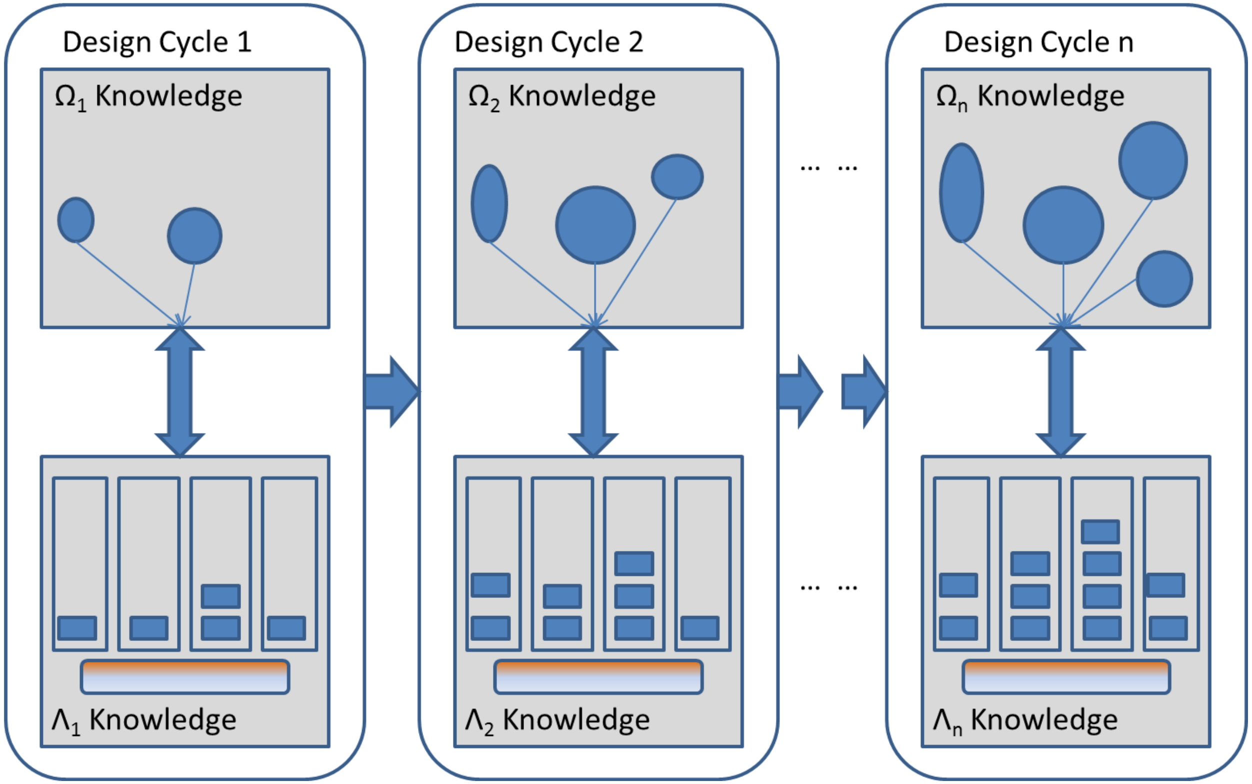
Technology and Science Evolution

- Technology and Science – A Creative Tension
  - Technology [Human Designed Artifacts] Evolves (Prescriptive Knowledge)
  - Science [Theories of Nature and Human Behaviors] Evolves (Descriptive Knowledge)

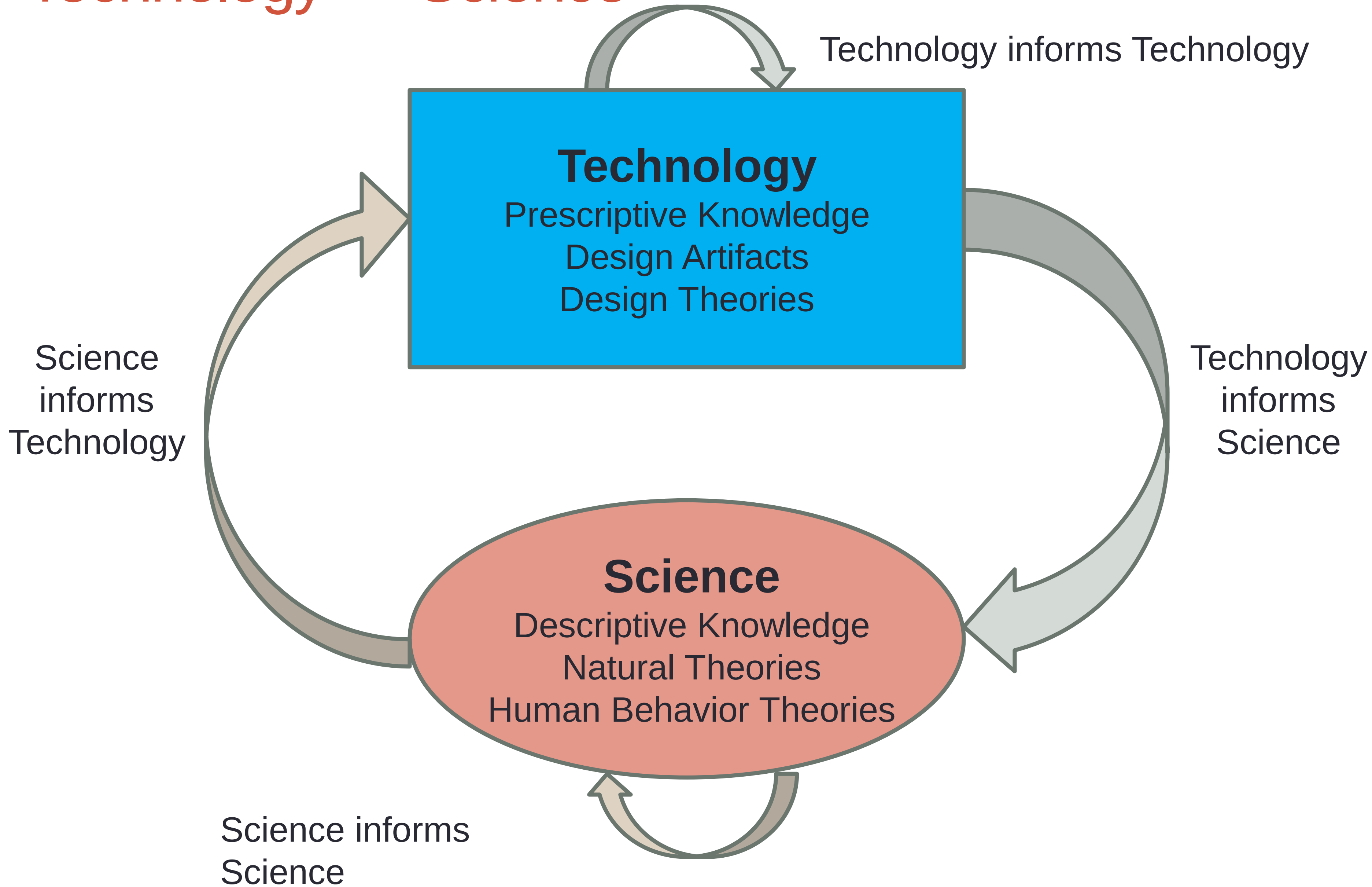
- Technology and Science have a complex relationship
  - Both evolve over time but at different rates and with different processes
  - Where does Innovation fit?
  - Where does Design fit?
  - Where does Learning fit?

Evolution is Growth of Knowledge

- Science = Descriptive Knowledge (Ω)
- Technology = Prescriptive Knowledge (Λ)
- Ref: Gregor & Hevner 2013 Appendix B



Technology ⇔ Science



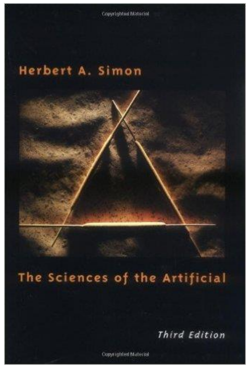
Observations

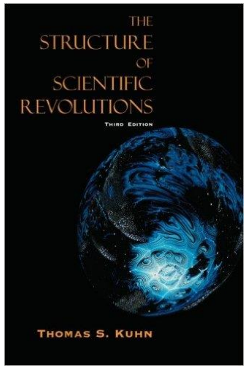
- Technology Evolution (TE)
  - Very Rapid, marked by continuous improvements
  - Process driven by human and economic utilities
  - Innovation economies
- Science Evolution (SE)
  - Slow, marked by paradigm shifts
  - Process driven by evaluation, gathering of empirical evidence, and hypothesis testing
- Technology Evolutions precede and drive Science Evolutions
  - Creative solutions to Relevant/Important opportunities
- Science Evolutions ground and direct Technology Evolutions
  - Growing knowledge bases and improved processes for scientific rigor and repeatability
- Questions
  - Who performs TE and SE?
  - Who funds TE and SE?
  - Who benefits from TE and SE?

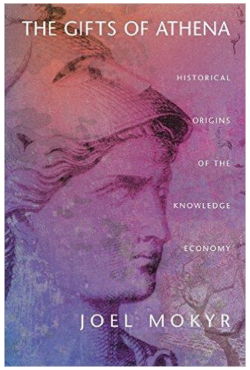
Implications for Learning

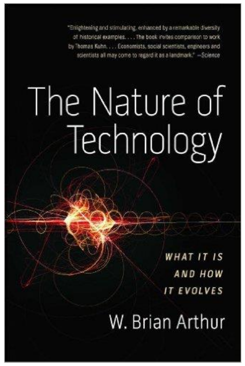
- Delivery of existing knowledge
  - Science and descriptive knowledge provides foundations for learning in a discipline
  - Technology and prescriptive knowledge provides awareness of current practices with existing concepts, models, methods and systems (tools)
  - Instruction in a subject must effectively balance science and technology
- Innovation for future evolution of the field
  - Challenge student with future opportunities to grow both technology and science
  - Teach innovation methods with a FEI-KIM model

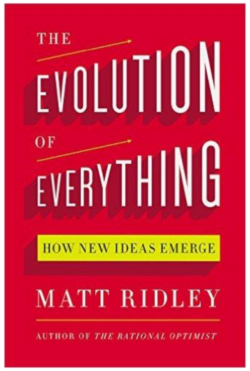
Essential References











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