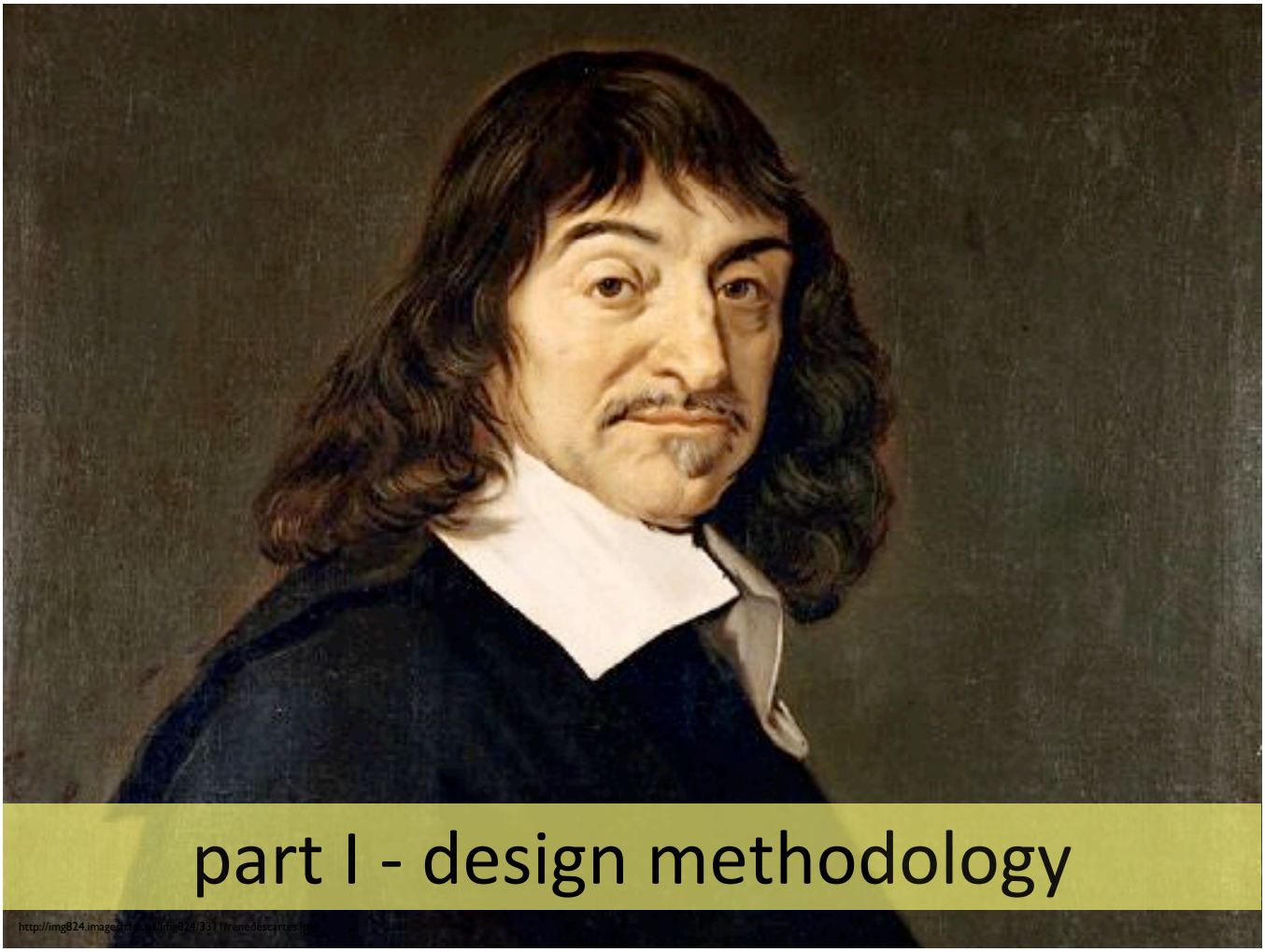
design science
research in IS

prepared by yves pigneur
DRIS April 2012

3

1. framework & publication
2. theory & anatomy
3. **methodology & action design**
4. patterns & evaluation
5. design rationale (C-K)



part I - design methodology

DISCOURS

DE LA METHODE

Pour bien conduire ſa raiſon, & chercher

la verité dans les ſciences.

PLUS

LA DIOPTRIQVE.

LES METEORES.

ET

LA GEOMETRIE.

Qui ſont des eſſais de cete METHODE.

A LEYDE

De l'Imprimerie de IAN MAIRE.

cIↃ IↃ c xxxvii.

Avec Privilege.

part II - action design research

1

design methodology

A design science research methodology for information systems research

Ken Peffers, Tuture Tuunanen, Marcus Rothenberger and Samir Chatterjee
Journal of the Management Information Systems, 2008, 24(3): 45-77

▸ see also [Vaishnavi and Kuechler, 2007] *Design science research methods and patterns* ch. 2-4

questions

what is the focus of the paper?

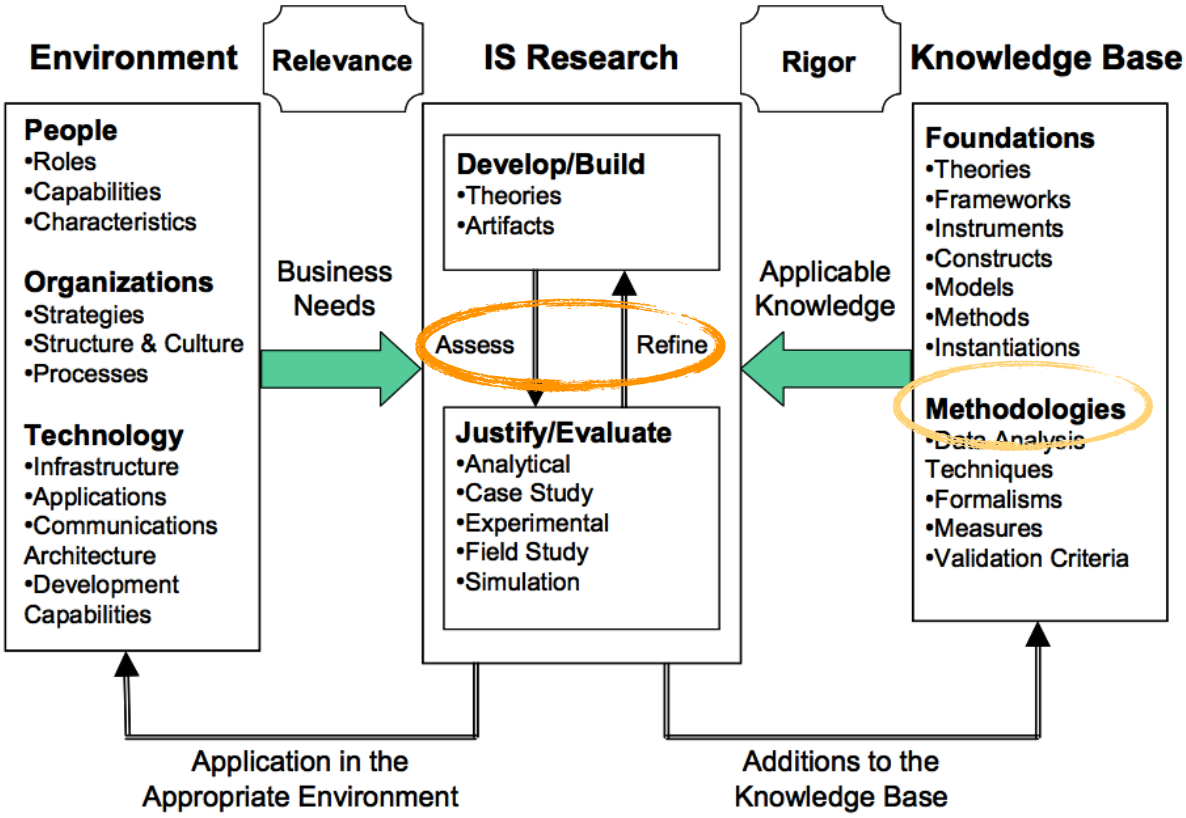
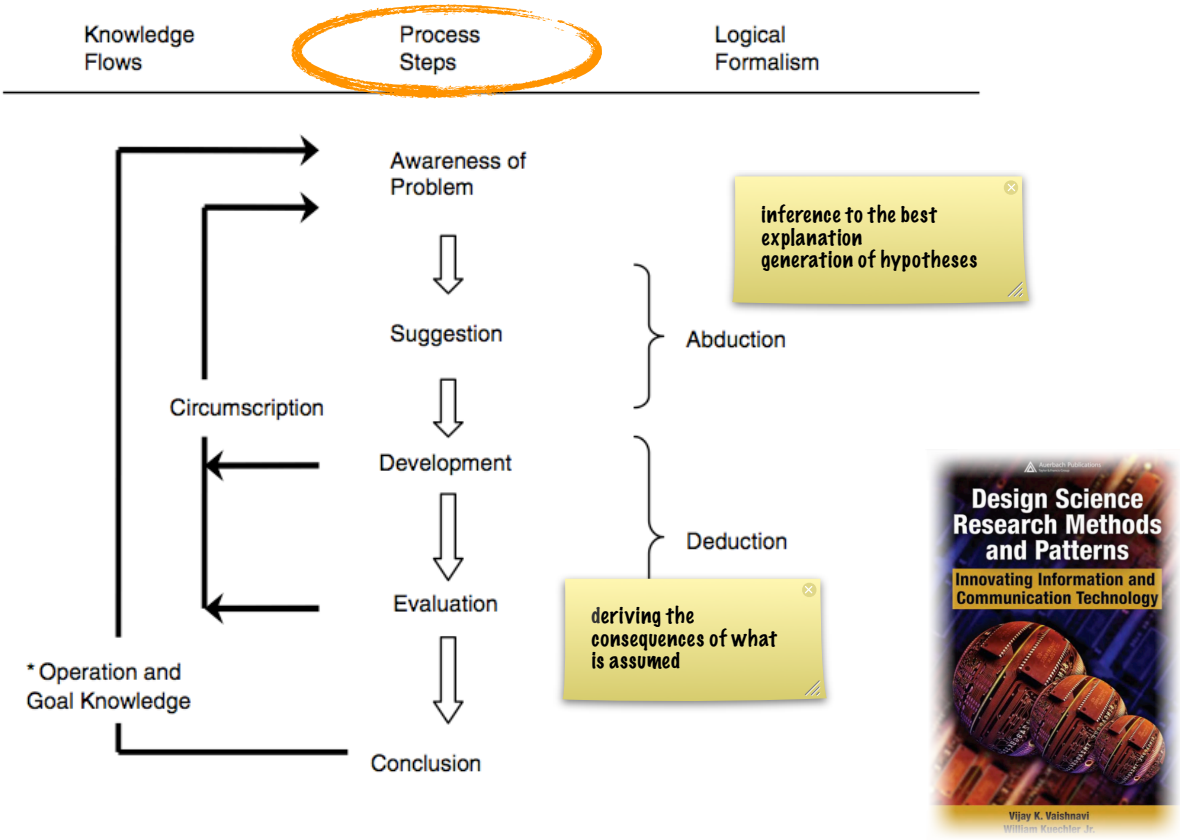


Figure 2. Information systems research framework



general design cycle (GDC)

adapted from [Vaishnavi and Kuechler, 2007] *Design science research methods and patterns*

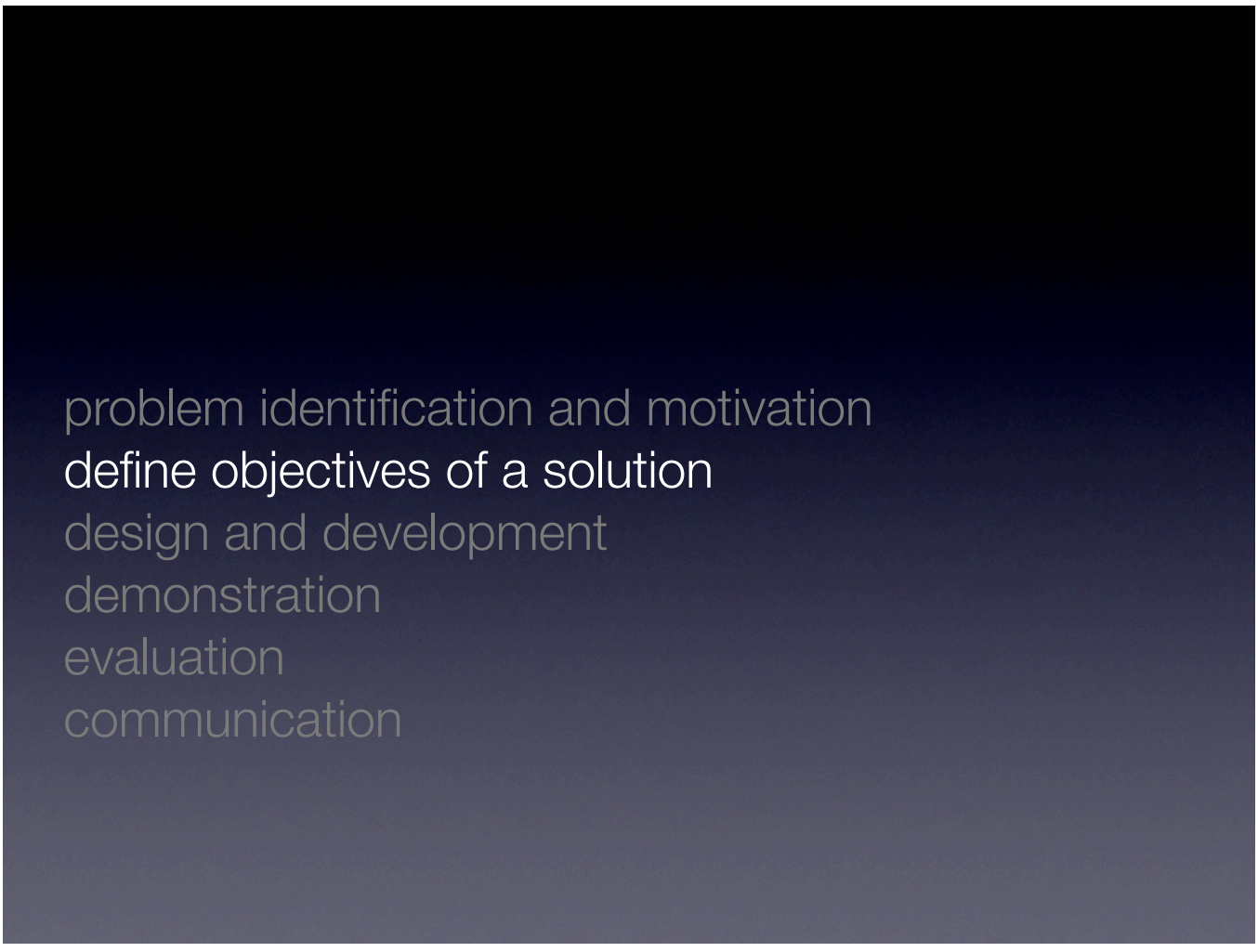
problem identification and motivation
define objectives of a solution
design and development
demonstration
evaluation
communication

question

what are the elements a methodology would include?

design science research methodology

- ✓ principles
  design science research defined > framework
- ✓ practice rules
  for design science research > guidelines
- ✓ procedures
  a process model and mental model for research outputs



questions

what are the main objectives of a design science process model?

how they compare to other methodologies?

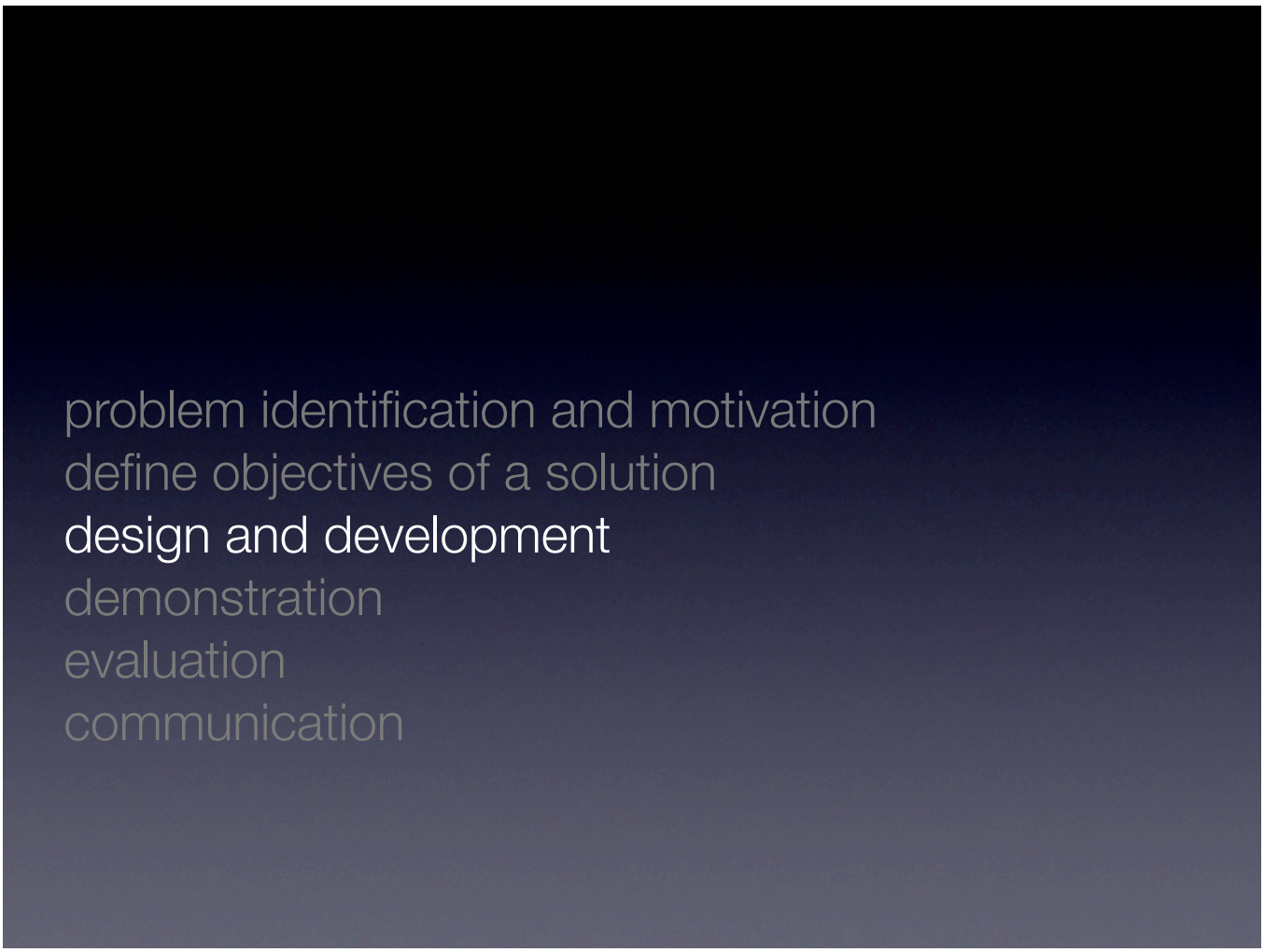
how to enter in the process?

design science process model

- a nominal process for the conduct of design science research
- built upon prior literature about design science in IS
- providing researchers with a mental model or template for a structure for research outputs

Common design process elements	Archer [2]	Takeda et al. [46]	Eekels and Roozenburg [14]	Nunamaker et al. [33]	Walls et al. [55]	Cole et al. [10] Rossi and Sein [40]	Hevner et al. [20]
Problem identification and motivation	Programming, data collection	Problem enumeration	Analysis	Construct a conceptual framework	Meta-requirements, kernel theories	Identify a need	Important and relevant problems
Objectives of a solution			Requirements				Implicit in "relevance"
Design and development	Analysis, synthesis, development	Suggestion, development	Synthesis, tentative design proposals	Develop a system architecture, analyze and design the system, build the system	Design method, meta design	Build	Iterative search process, artifact
Demonstration			Simulation, conditional prediction	Experiment, observe, and evaluate the system			
Evaluation		Confirmatory evaluation	Evaluation, decision, definite design		Testable design process/product hypotheses	Evaluate	Evaluate
Communication	Communication						Communication

Table 1 : design and process elements from IS



question

what are the main activities of a design science research methodology process?

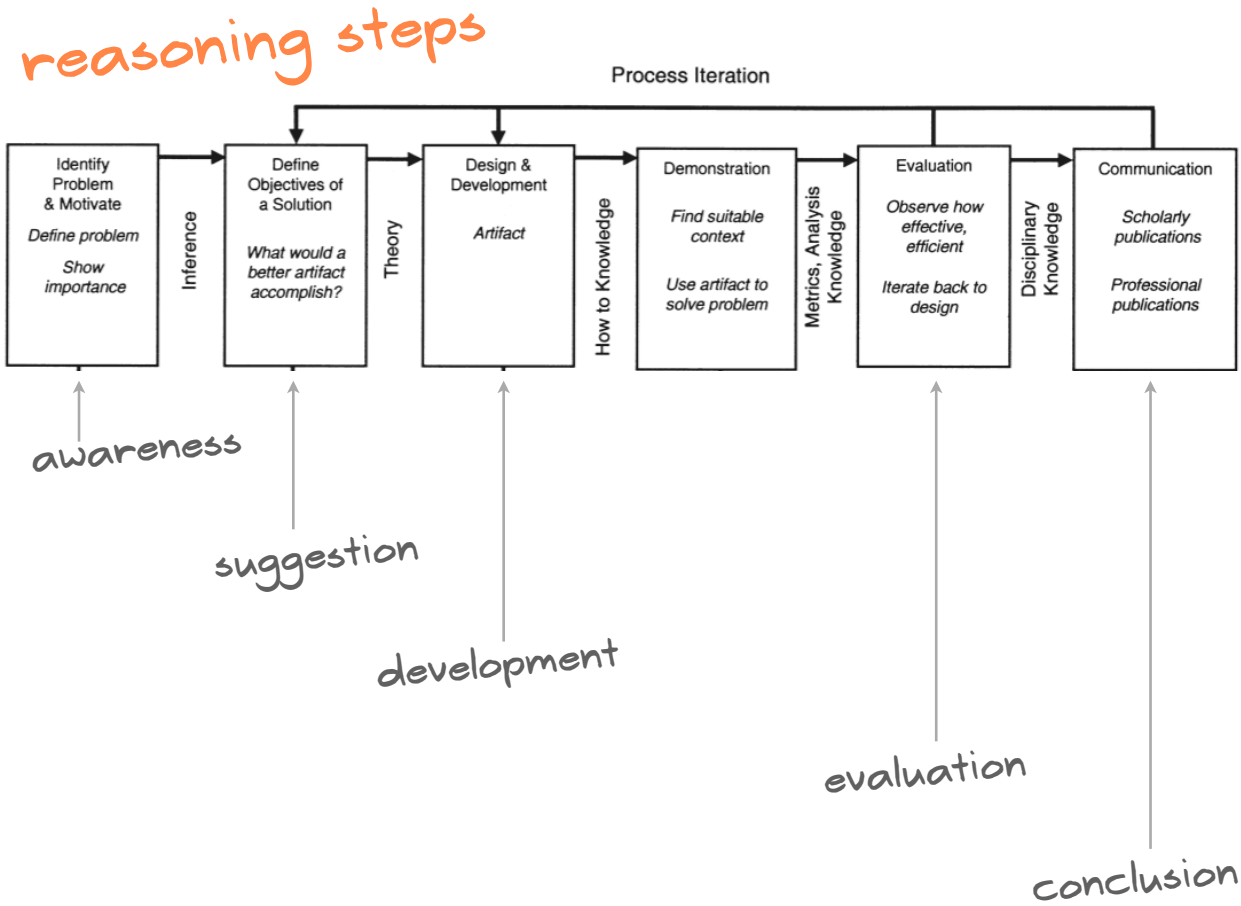


Figure 1: DSRM process model


steps


1. problem identification

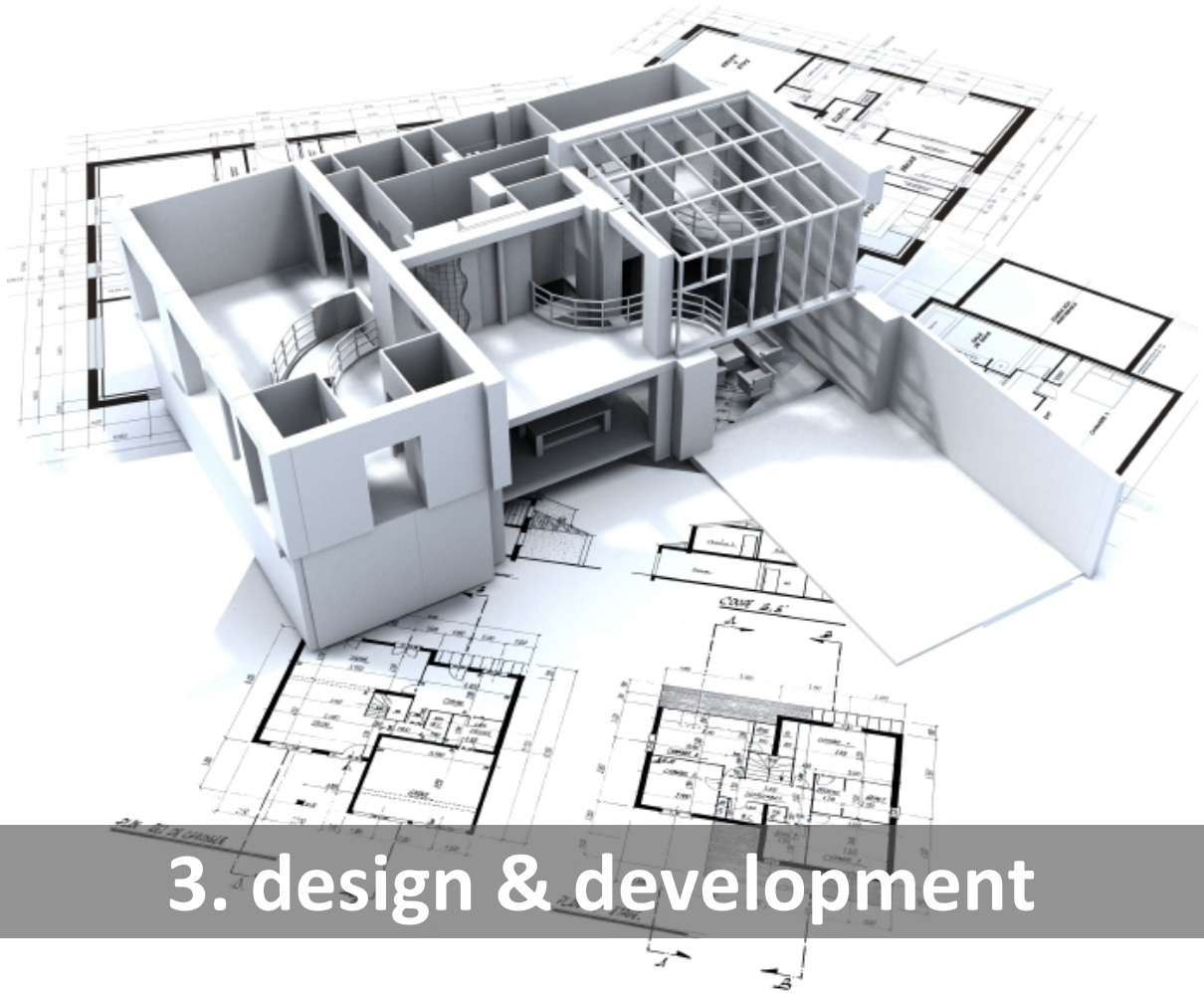
1. problem identification and motivation

- ✓ design begins with an awareness of the problem
- ✓ define the specific research problem and justify the value of a solution
- ✓ design research is sometimes called “improvement research” since it solves a problem better

2. define the objectives for a solution

- ✓ infer the objectives of a solution from the problem definition and knowledge of what is possible and feasible
- ✓ suggestion for a problem solution are abductively drawn from the existing knowledge/theory base for the problem area

meta-requirements



3. design & development

3. design and development

✓ specification and creation of the artifact according to the suggested solution

meta-design

4. demonstration

✓ demonstrate the use of the artifact to solve one or more instances of the problem

artifact

5. evaluation

- ✓ observe and measure how well the artifact supports a solution to a problem

- ✓ at the end,
  success: stop
  failure: iterate back to previous activity

6. communication

6. communication

- ✓ communicate the problem and its importance, the artifact, its utility and novelty, the rigor of the design, and its effectiveness
- publications ...

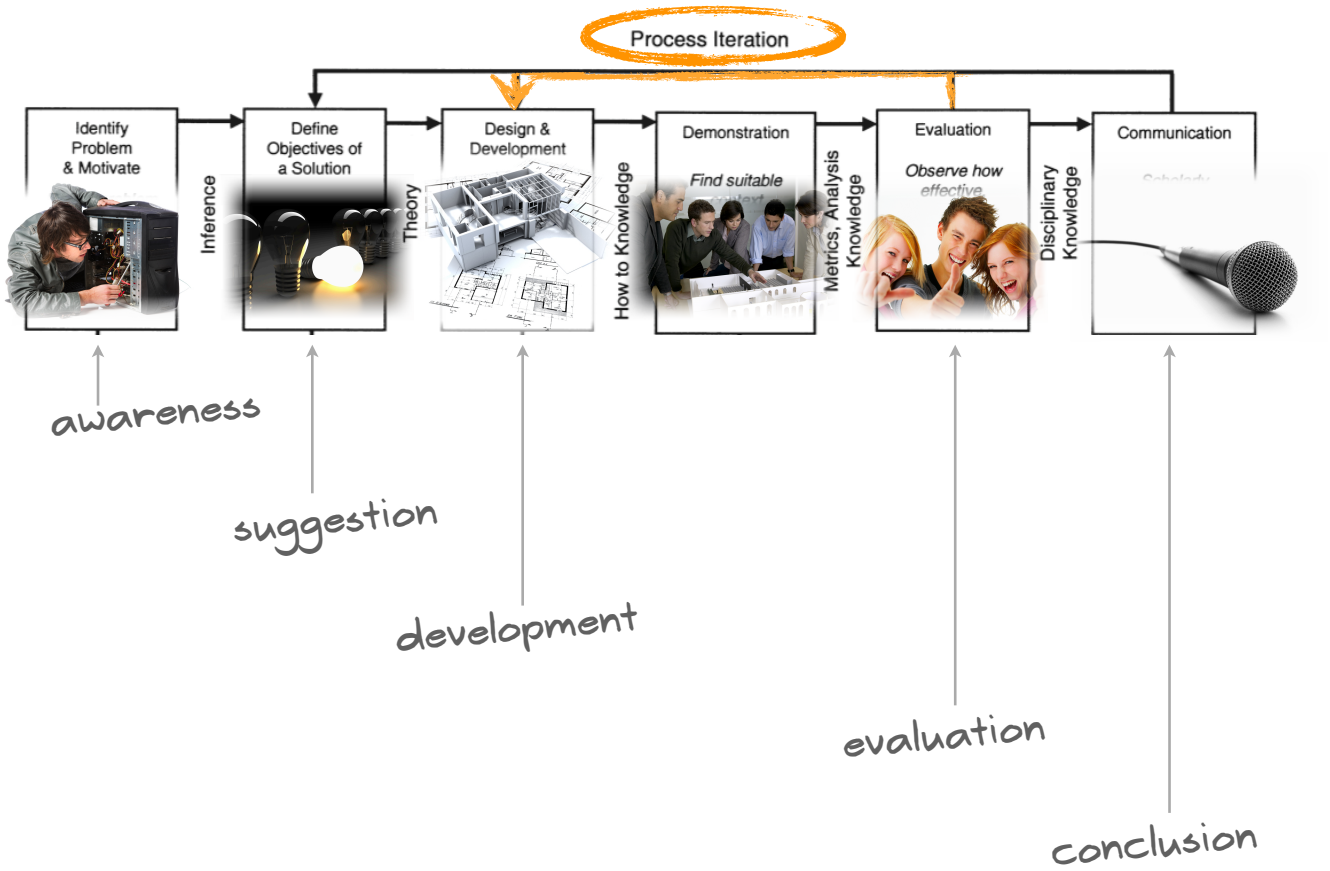
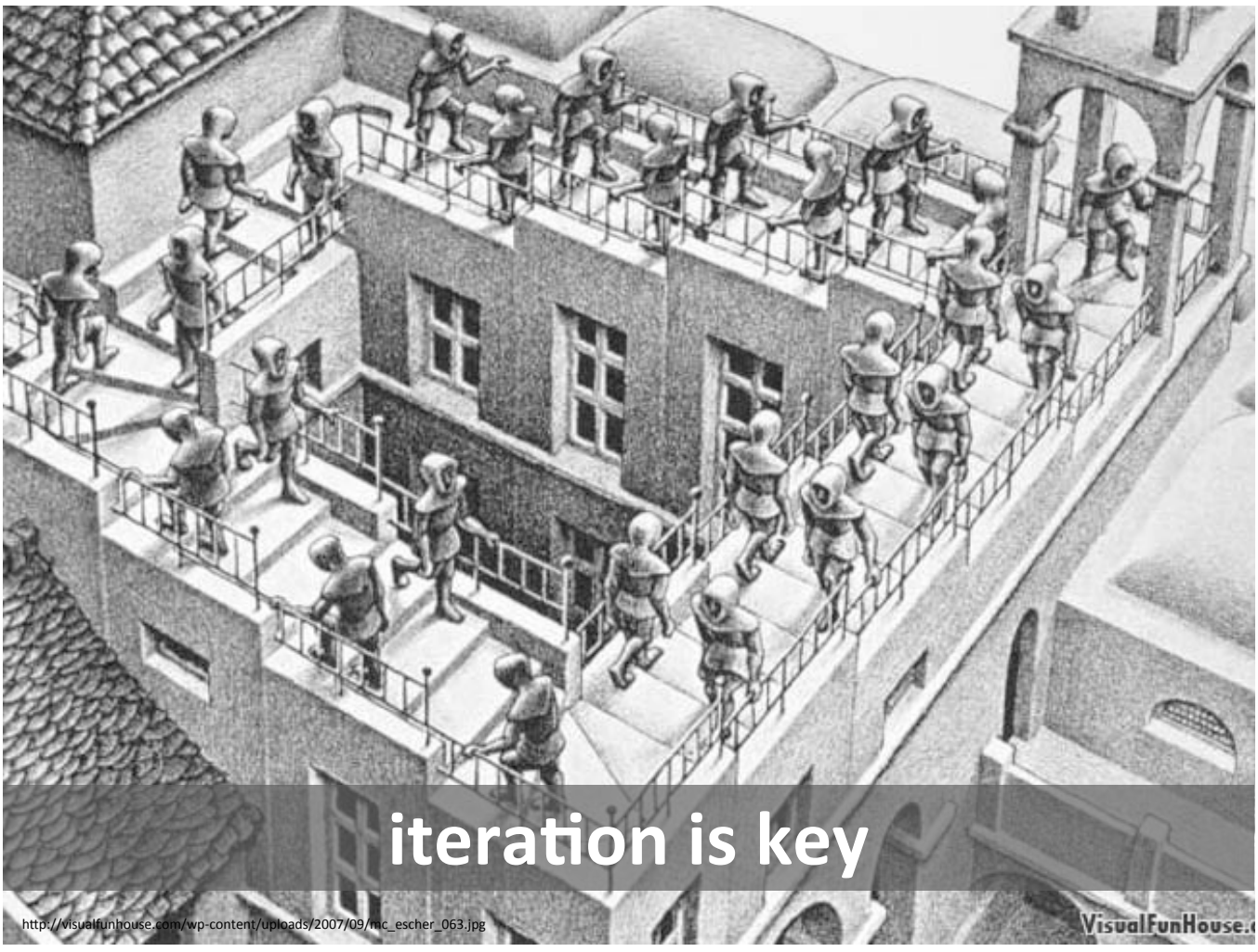


Figure 1: DSRM process model



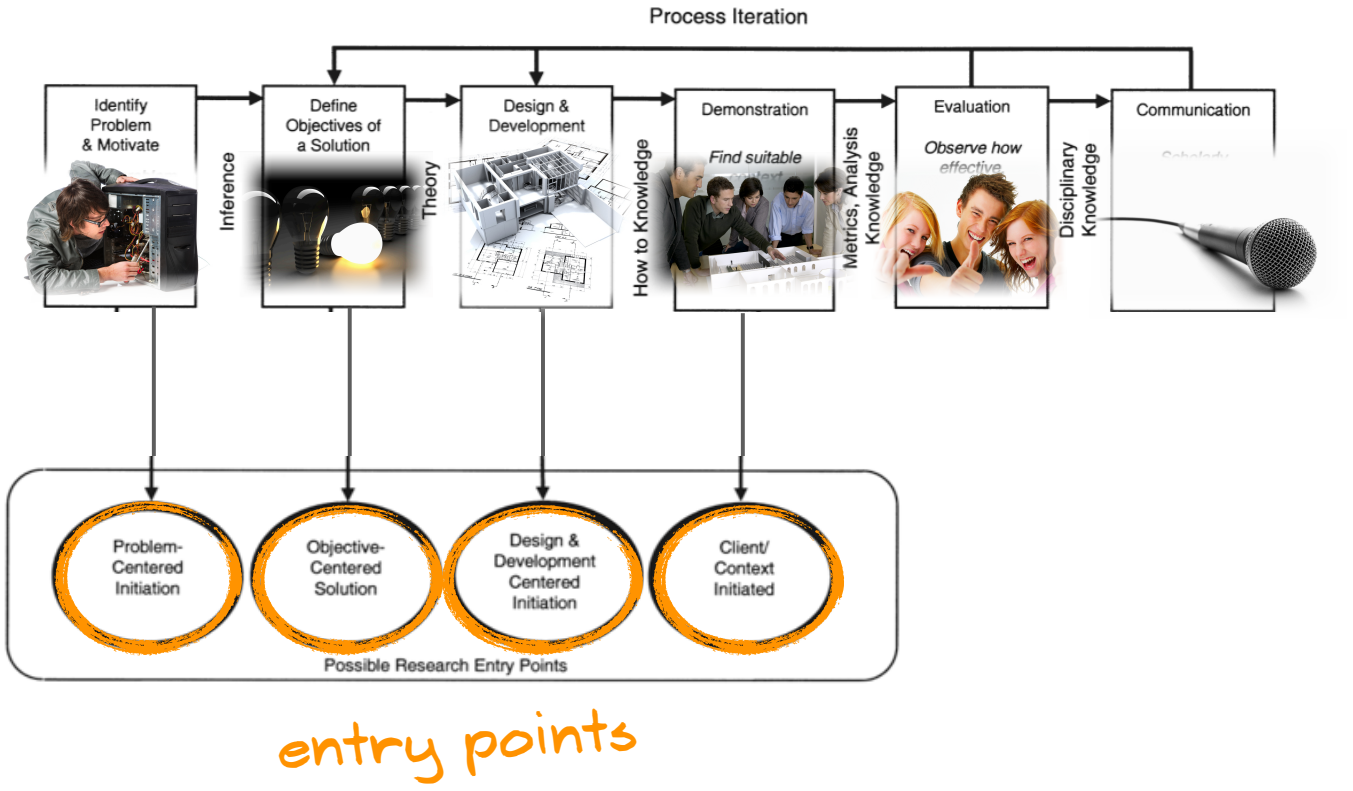


Figure 1: DSRM process model

problem identification and motivation
define objectives of a solution
design and development
demonstration
evaluation
communication

questions

how to illustrate the DSRM process?

and the entry points?

CATCH data warehouse for health status assessments

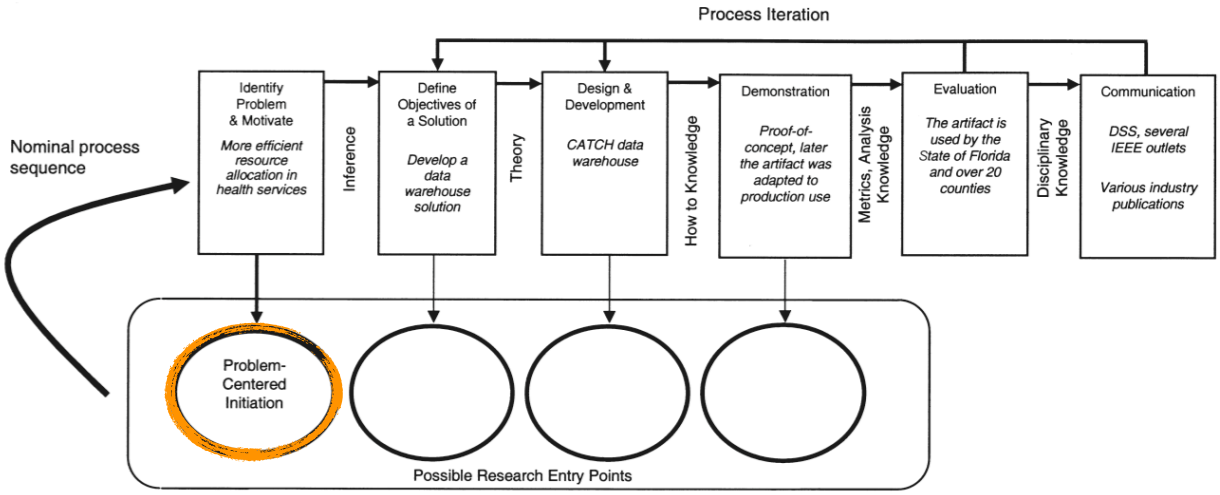


Figure 2: DSRM process for the *CATCH* project (datawarehousing for healthcare)

a software reuse measure developed at *MBA Technologies*

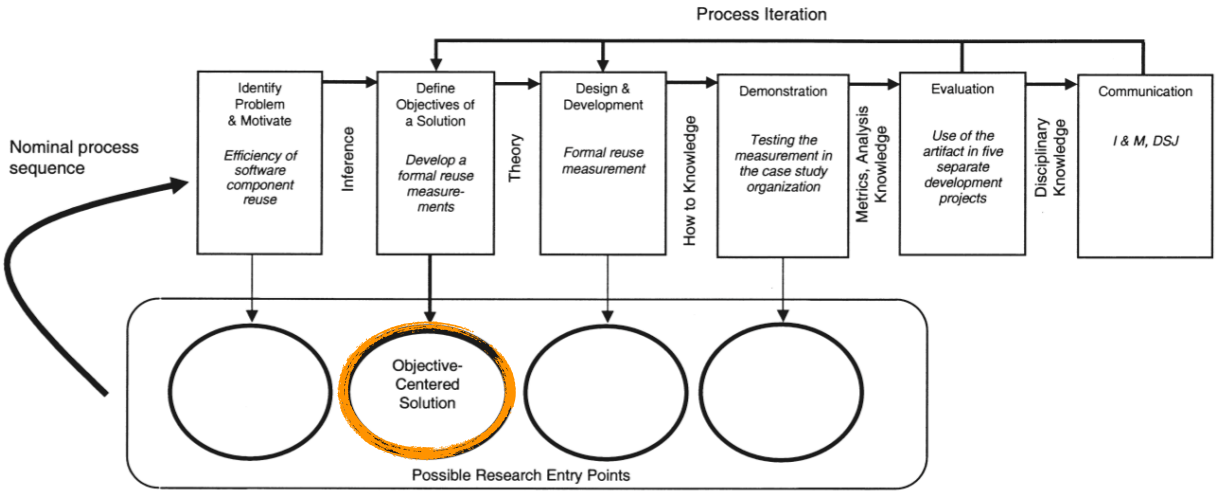


Figure 3: DSRM process for the *MBA Technologies* (software reuse and metrics)

SIP-based voice- and video-over IP software

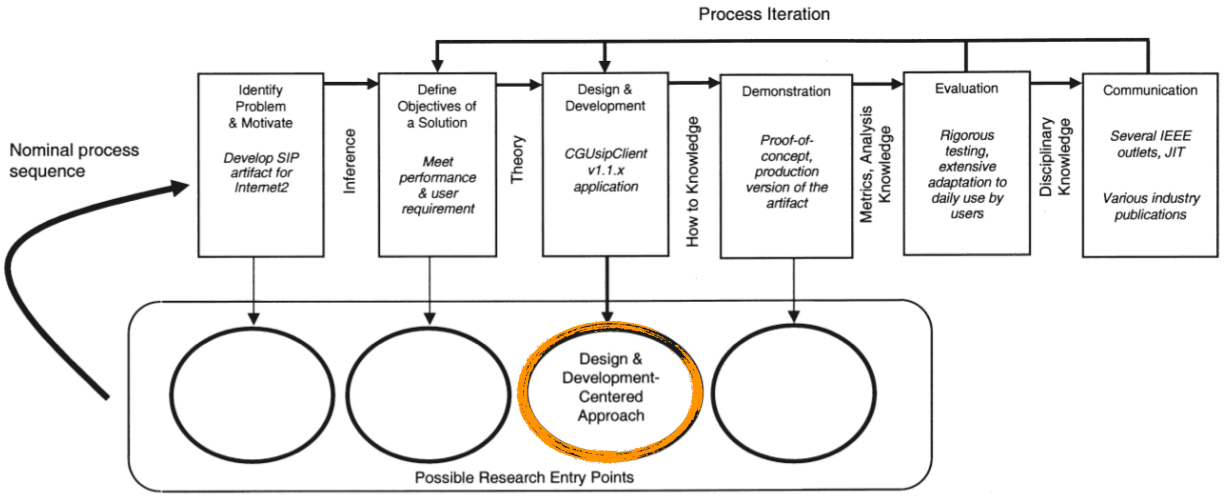


Figure 4: DSRM process for the *CGUsipClient* (from voice over IP to video over IP)

a method at *Digia* to generate ideas for new applications

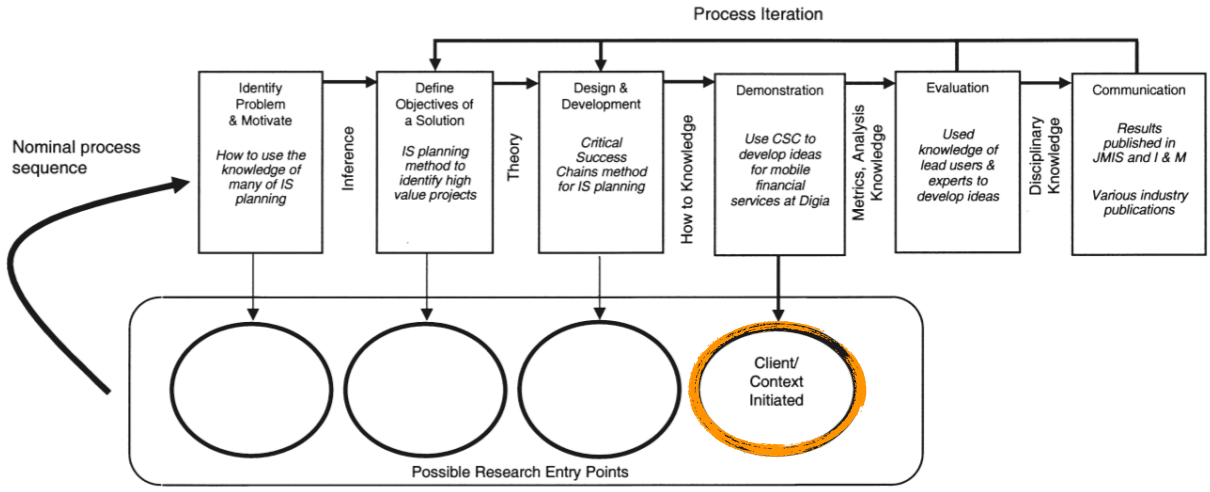
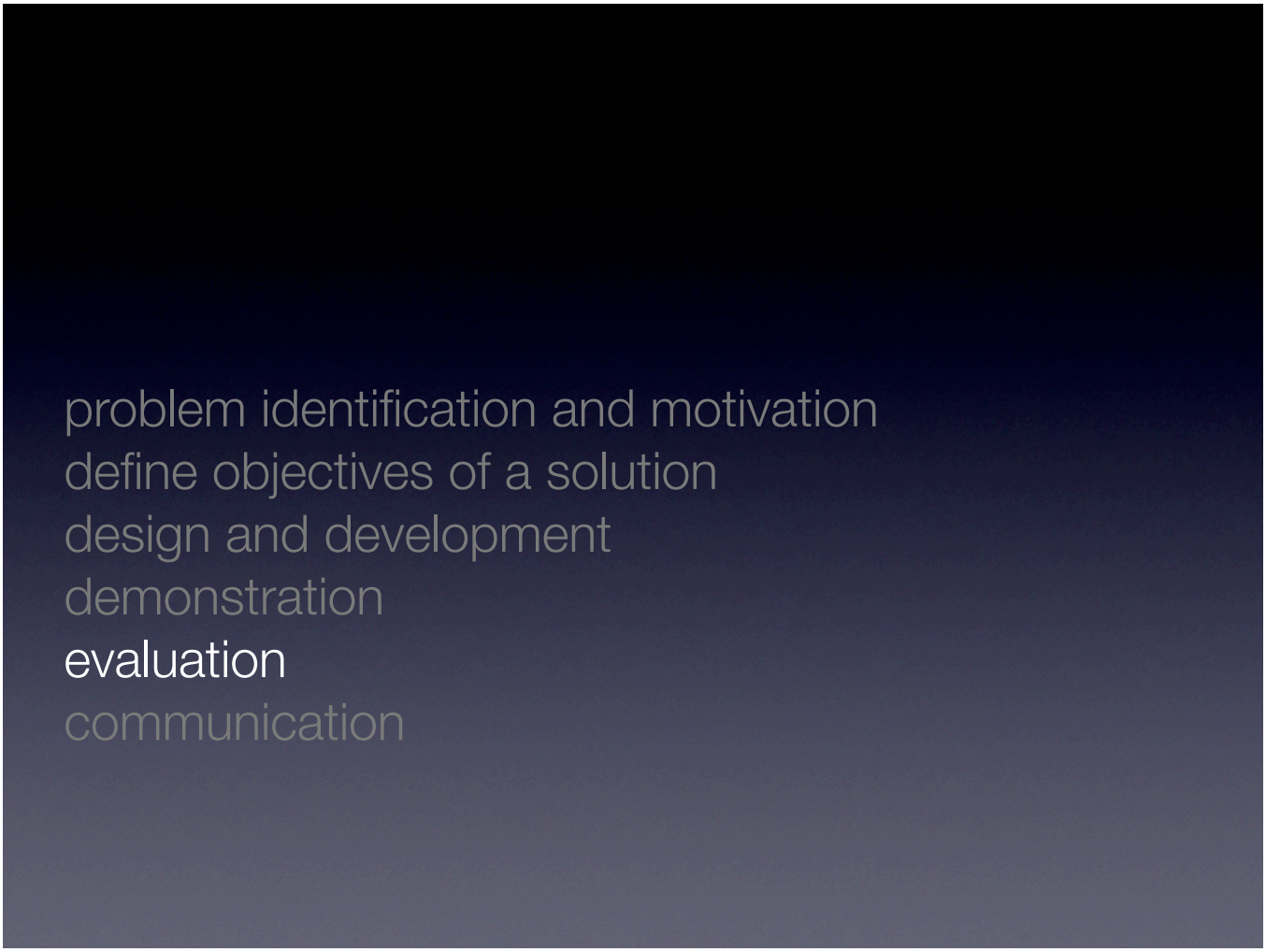


Figure 5: DSRM process for the *Digia* Study (idea generation for IS projects)



questions

what are the main advantages of a formal DSRM process?

what are the similarities with action research?

what are the differences between design research and design?

problem identification and motivation
define objectives of a solution
design and development
demonstration
evaluation
communication

questions

what could be alternatives for this design science research methodology?

alternatives

1.curiosity design research

2.context-specific design research

3.action research

design science research

> “ The fundamental principle of design-science research is that knowledge and understanding of a design problem and its solution are acquired in the building and application of an artifact. ”
>
> - Samir Chatterjee, Claremont Graduate University

part II - action design research

2

action design research

Action Design Research

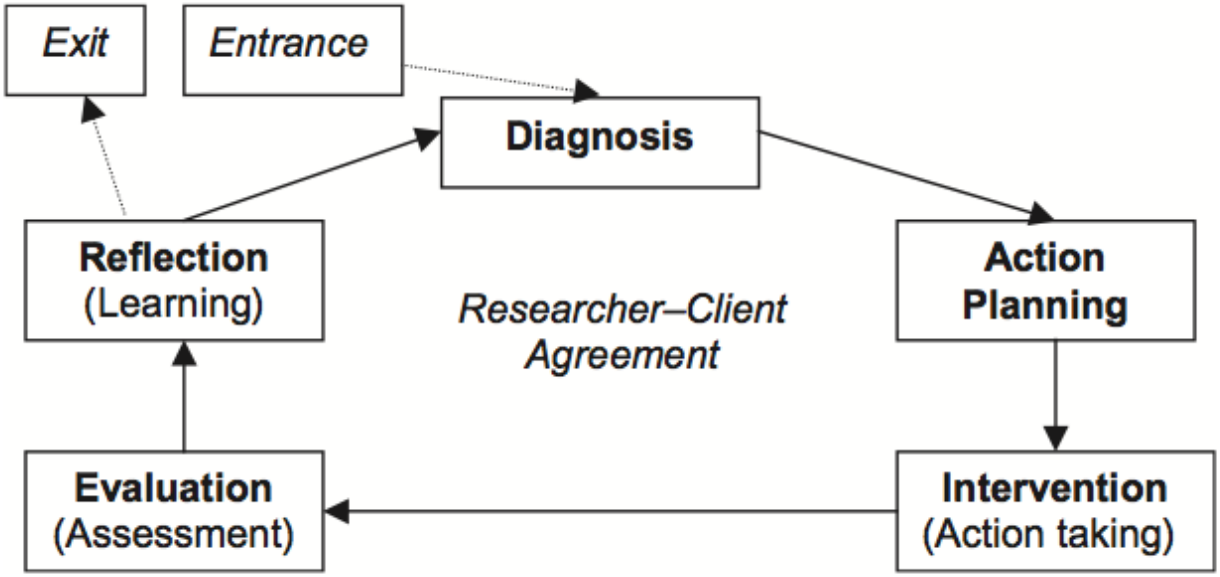
Maug Sein, Ola Henfridsson, Sandeep Purao, Matti Rossi & Rikard Lindgren
MIS Quarterly, 2010, 35(1): 37–56.

FYI

Principles of canonical action research

Robert M. Davison, Maris G. Martinsons & Ned Kock
Info Systems Journal (2004) 14, 65–86

Cyclical Process Model (CPM)



research question

a new design research method that simultaneously aims at

- building innovative IT artifacts in an organizational context and

- learning from the intervention while addressing a problematic situation

need for a new design research method
the ADR method
ADR at Volvo

questions

why a new design research method is needed?

problem of sequencing and separation

the prevailing approach to DR

- ✓ is captured in the *“build and then evaluate”*
- ✓ it considers organizational intervention to be secondary
- ✓ it does not meet the needs of a research method that has built-in relevance and rigor cycles for designing artifacts

>>>
need for a research approach that has organizational intervention at its very heart

incorporating action

merging design research and action research

Action Design Research (ADR)

a new research method to conduct design research that recognizes that the artifact emerges from interaction with the organizational context even when its initial design is guided by the researchers’ intent.

need for a new design research method

the ADR method

ADR at Volvo

questions

what are the two disparate challenges ADR has to deal with?

challenges ...

1. addressing a problem situation encountered in a specific organizational setting by intervening and evaluating, and

2. constructing and evaluating an IT artifact that addresses the class of problems typified by the encountered situation

critical issues

1. evaluation efforts cannot follow building in a sequence as suggested in prior, stage-gate models of DR

2. controlled evaluation efforts are difficult to design and conduct

3. innovation must be defined for the class of systems typified by the ensemble artifact

stages

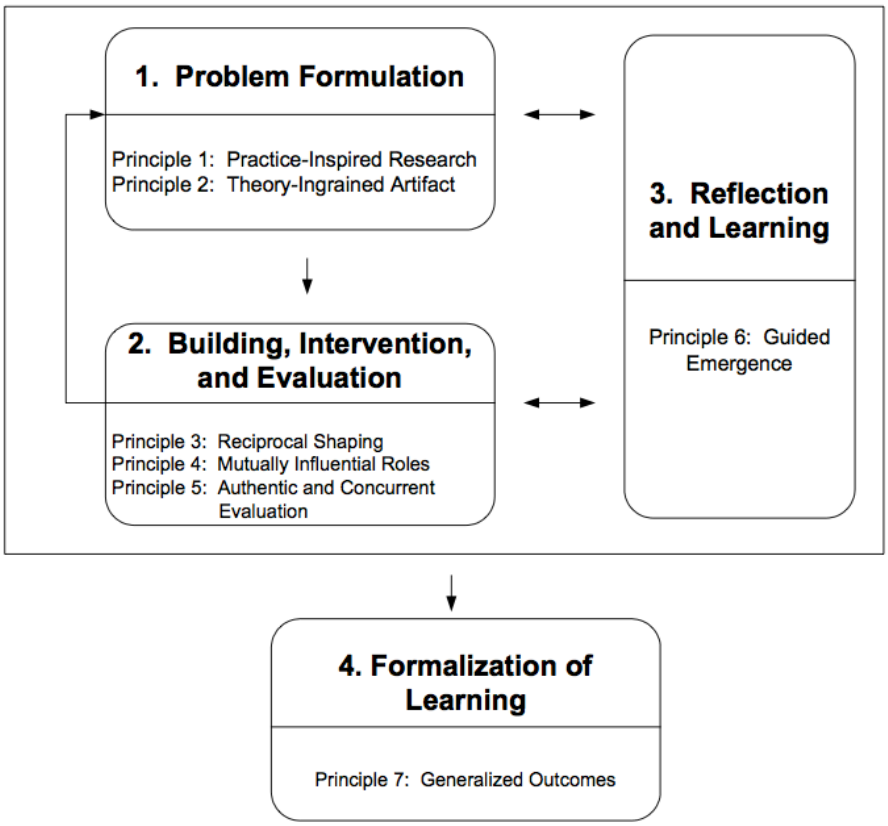


Figure 1: ADR method: stages and principles

PROBLEM FORMULATION

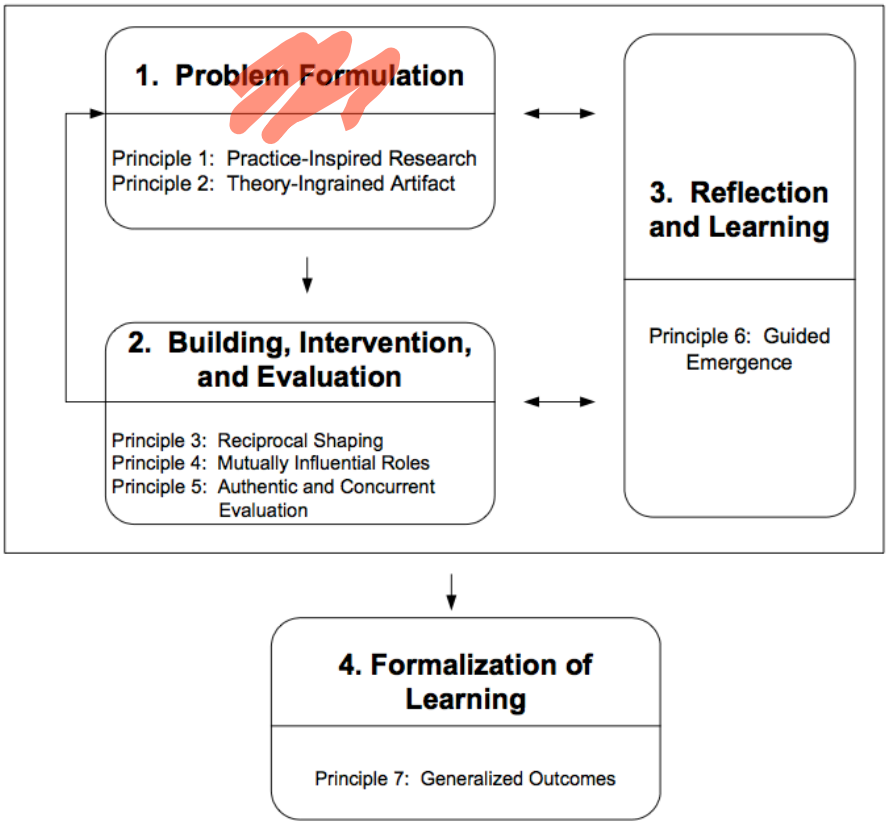


Figure 1: ADR method: stages and principles

1. problem formulation

1. Identify and conceptualize the research opportunity
2. Formulate initial research questions
3. Cast the problem as an instance of a class of problems
4. Identify contributing theoretical bases and prior technology advances
5. Secure long-term organizational commitment
6. Set up roles and responsibilities

1

Figure 2: tasks in the problem formulation stage

principle 1 - practice-inspired research

1

the action design researcher should generate knowledge that can be applied to the class of problems that the specific problem exemplifies. As a result, the research activity is problem-inspired.

principle 2 - theory-ingrained artifact

2

the action design researcher actively inscribes theoretical elements in the ensemble artifact, thus manifesting the theory “in a socially recognizable form”

BUILDING, INTERVENTION AND EVALUATION

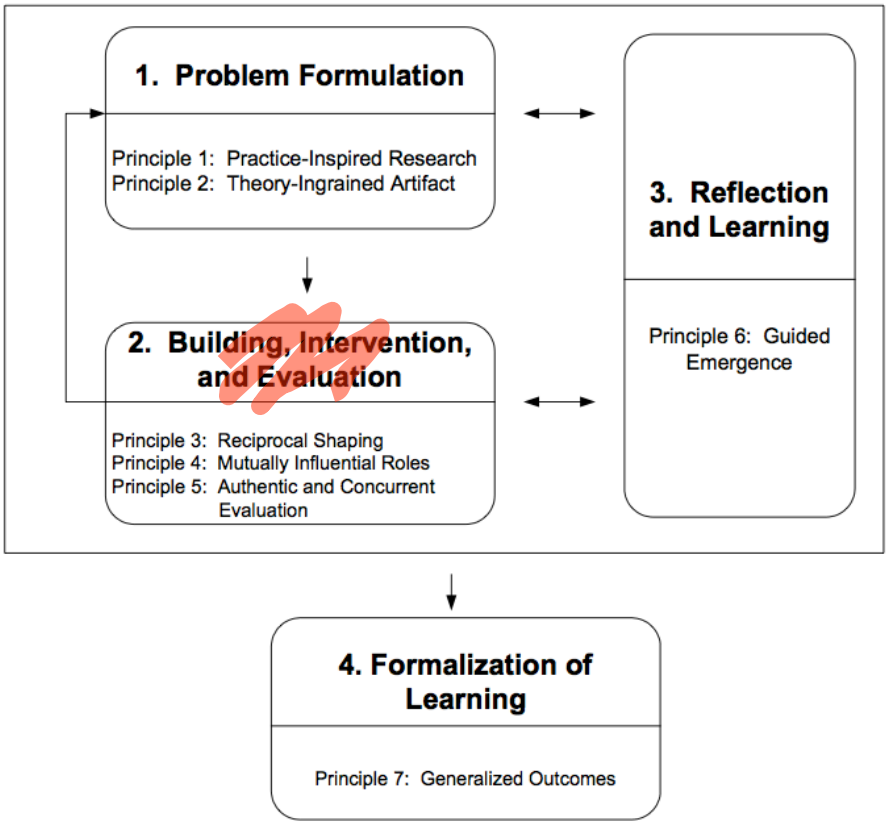


Figure 1: ADR method: stages and principles

2

2. building, intervention and evaluation (BIE)

1. Discover initial knowledge-creation target
2. Select or customize BIE form
3. Execute BIE cycle(s)
4. Assess need for additional cycles, repeat

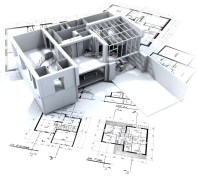


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Figure 5: tasks in building, intervention and evaluation stage

IT-dominant BIE

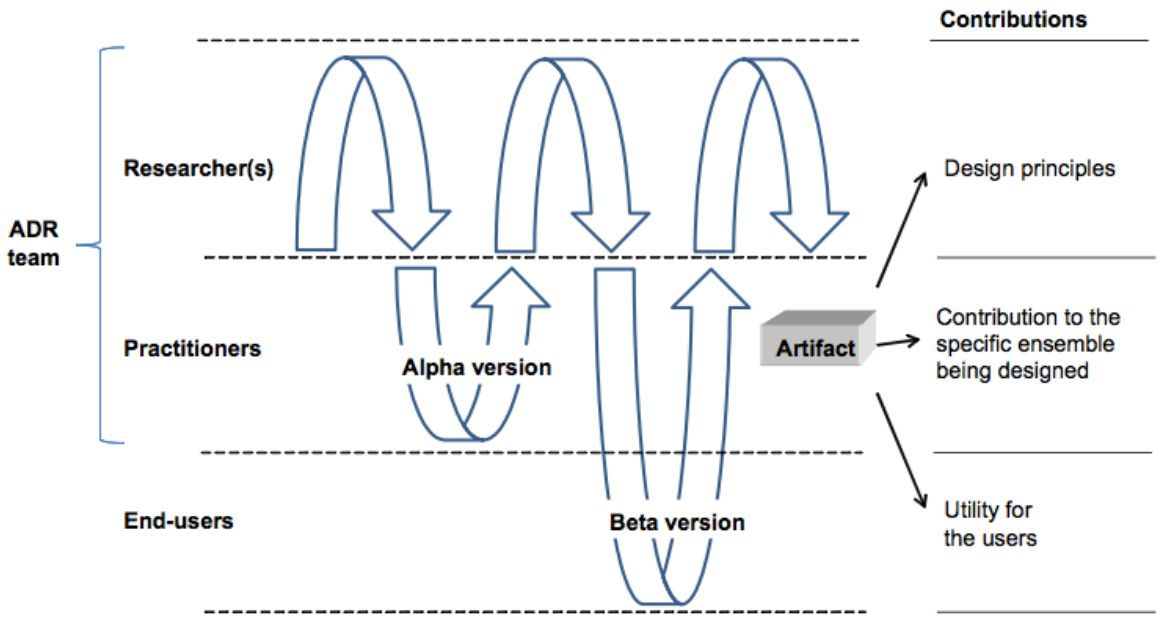


Figure 3: the generic schema for IT-dominant BIE

Organization-dominant BIE

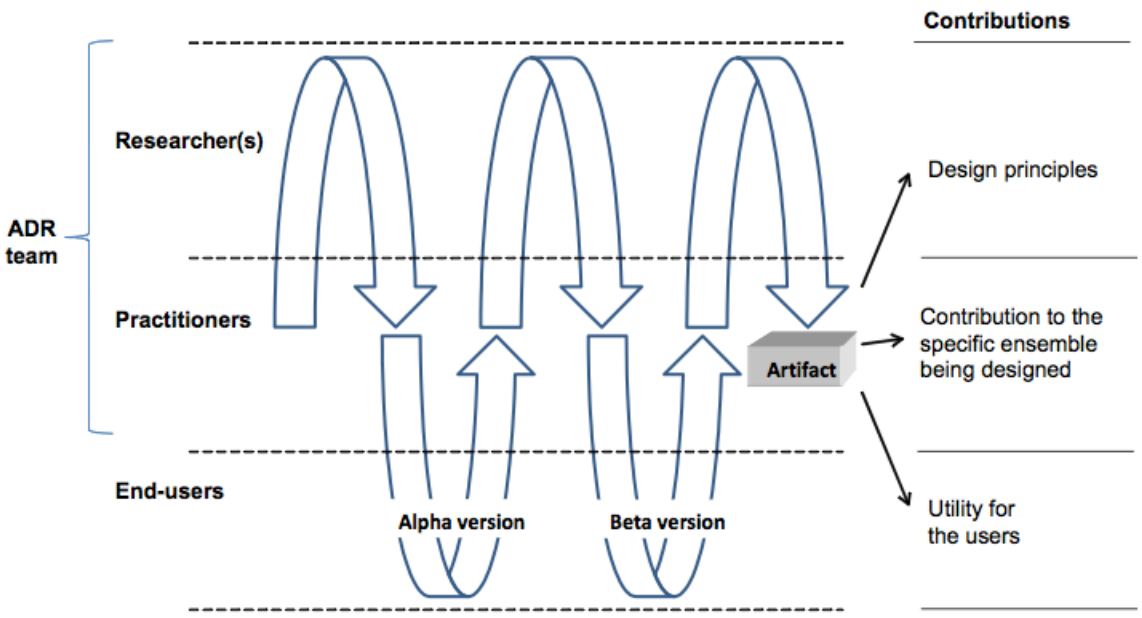


Figure 4: the generic schema for organization-dominant BIE

principle 3 - reciprocal shaping

3

the principle emphasizes the inseparable influences mutually exerted by the two domains:

✓ the IT artifact and

✓ the organizational context

principle 4 - mutually influential roles

4

the principle points to the importance of mutual learning among the different project participants

- ✓ the action design researchers bring their knowledge of theory and technological advances
- ✓ the practitioners bring practical hypotheses and knowledge of organizational work practices.

principle 5 - authentic and concurrent evaluation

5

the principle emphasizes a key characteristic of ADR: evaluation is not a separate stage of the research process that follows building.

decisions about designing, shaping, and reshaping the ensemble artifact and intervening in organizational work practices should be interwoven with ongoing evaluation

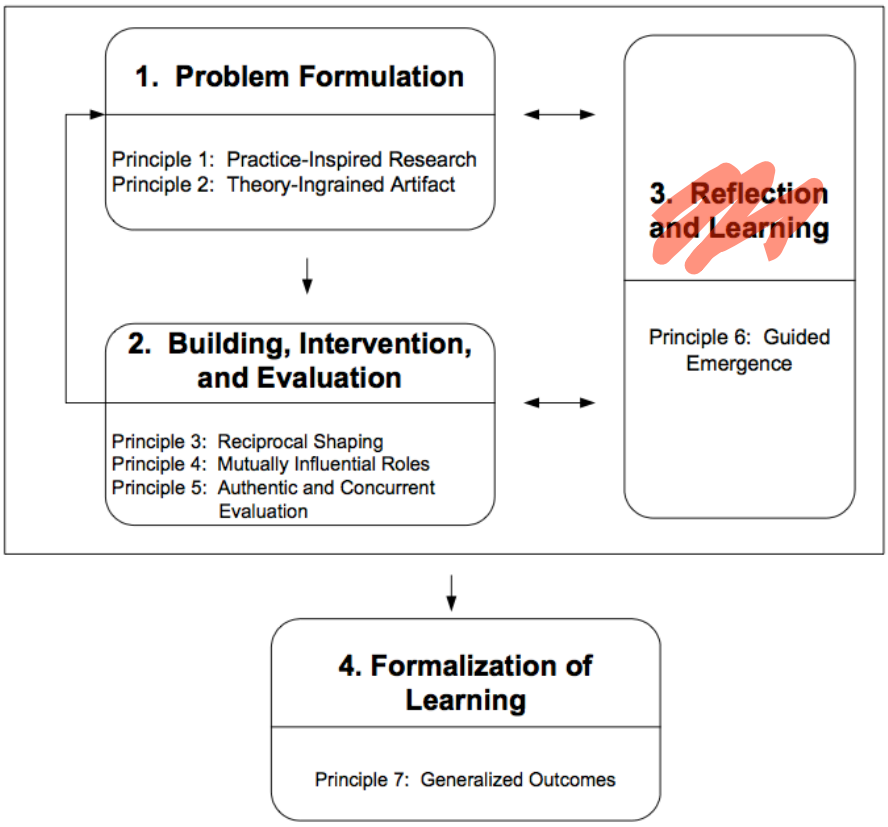
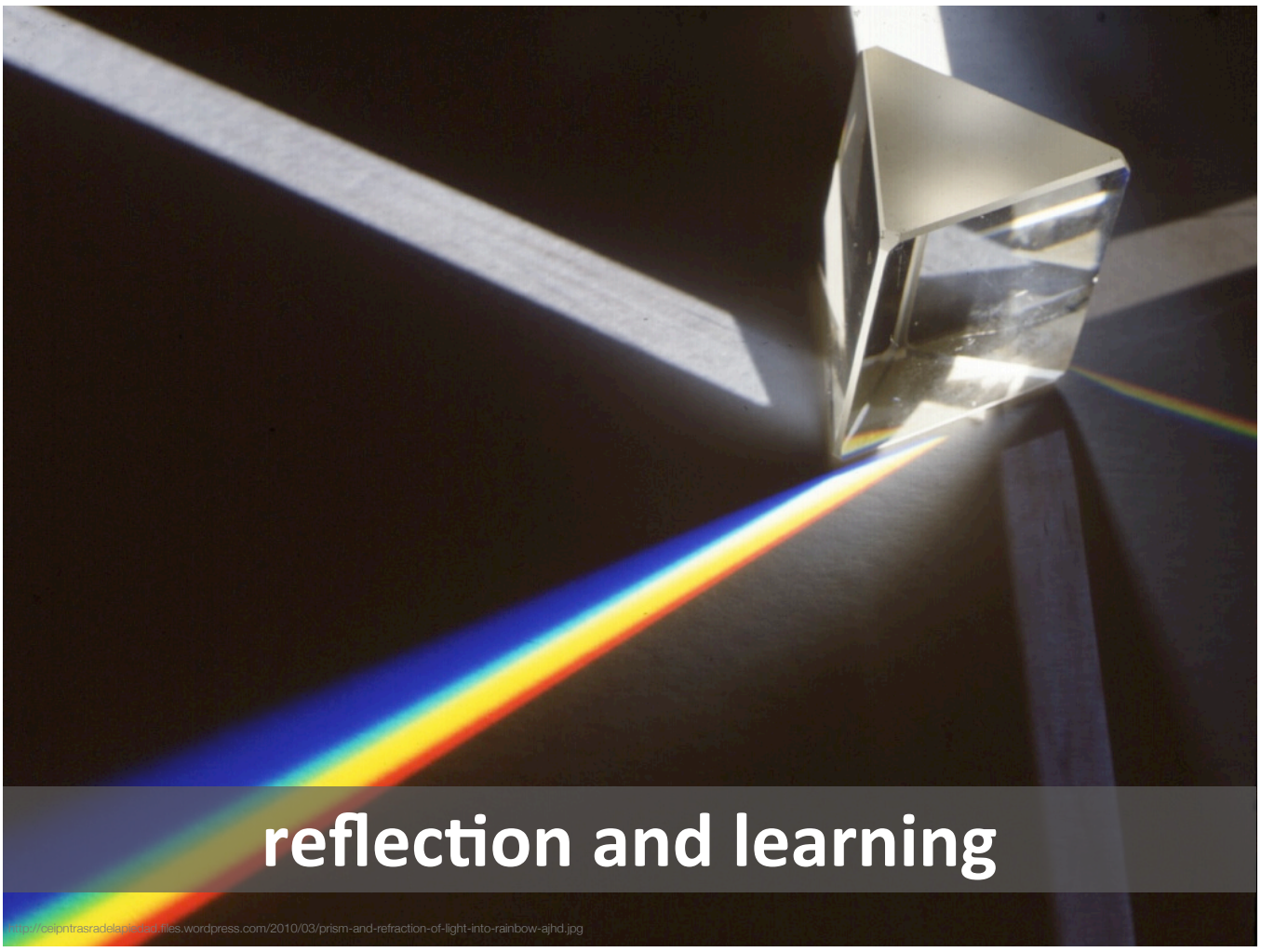


Figure 1: ADR method: stages and principles



Jean Piaget

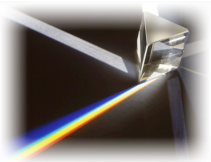
http://psychology.about.com/od/historyofpsychology/tp/ten-influential-psychologists.htm

reflecting abstraction

http://www.travelsmart.gov.au/schools/schools2.html

3. reflection and learning

1. Reflect on the design and redesign during the project
2. Evaluate adherence to principles
3. Analyze intervention results according to stated goals



3

Figure 6: tasks in reflection and learning stage

6

principle 6 - guided emergence

the principle, therefore, uses the term guided emergence to capture a vital trait of ADR: the interplay between the two seemingly conflicting perspectives:

design implies external, intentional intervention

emergence conveys a sense of organic evolution

oxymora

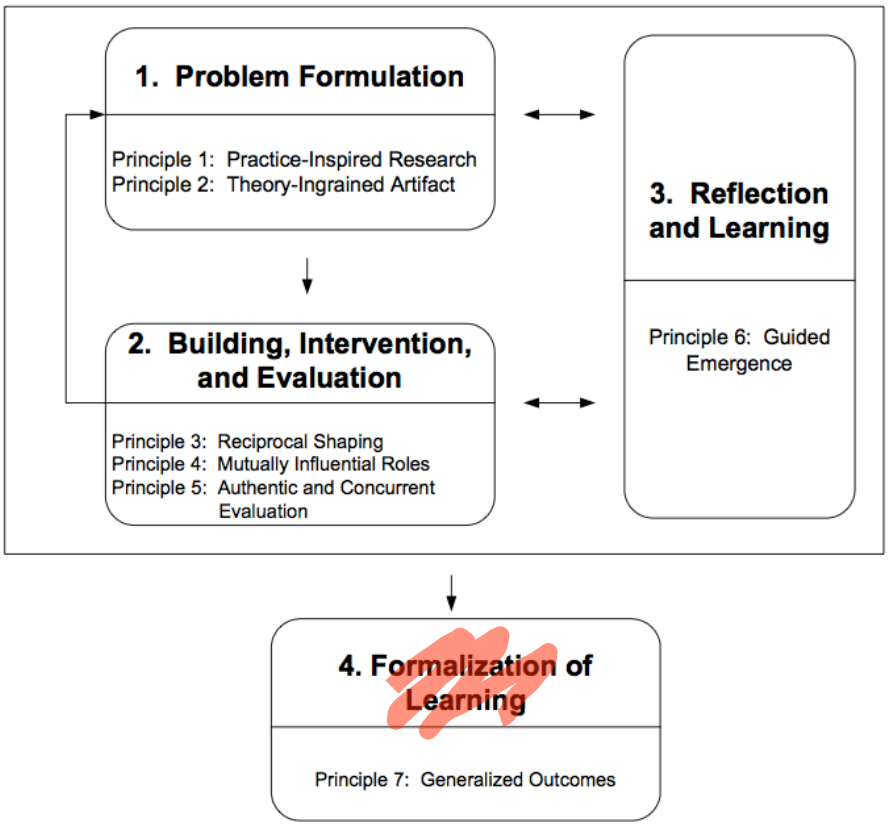


Figure 1: ADR method: stages and principles

4. formalization of learning

1. Abstract the learning into concepts for a class of field problems
2. Share outcomes and assessment with practitioners
3. Articulate outcomes as design principles
4. Articulate learning in light of theories selected
5. Formalize results for dissemination

Figure 7: tasks in formalization of learning stage

principle 7 - generalized outcomes

move from the specific-and-unique to generic-and-abstract, in three levels:

1. generalization of the problem instance,
2. generalization of the solution instance, and
3. derivation of design principles from the design research outcomes.

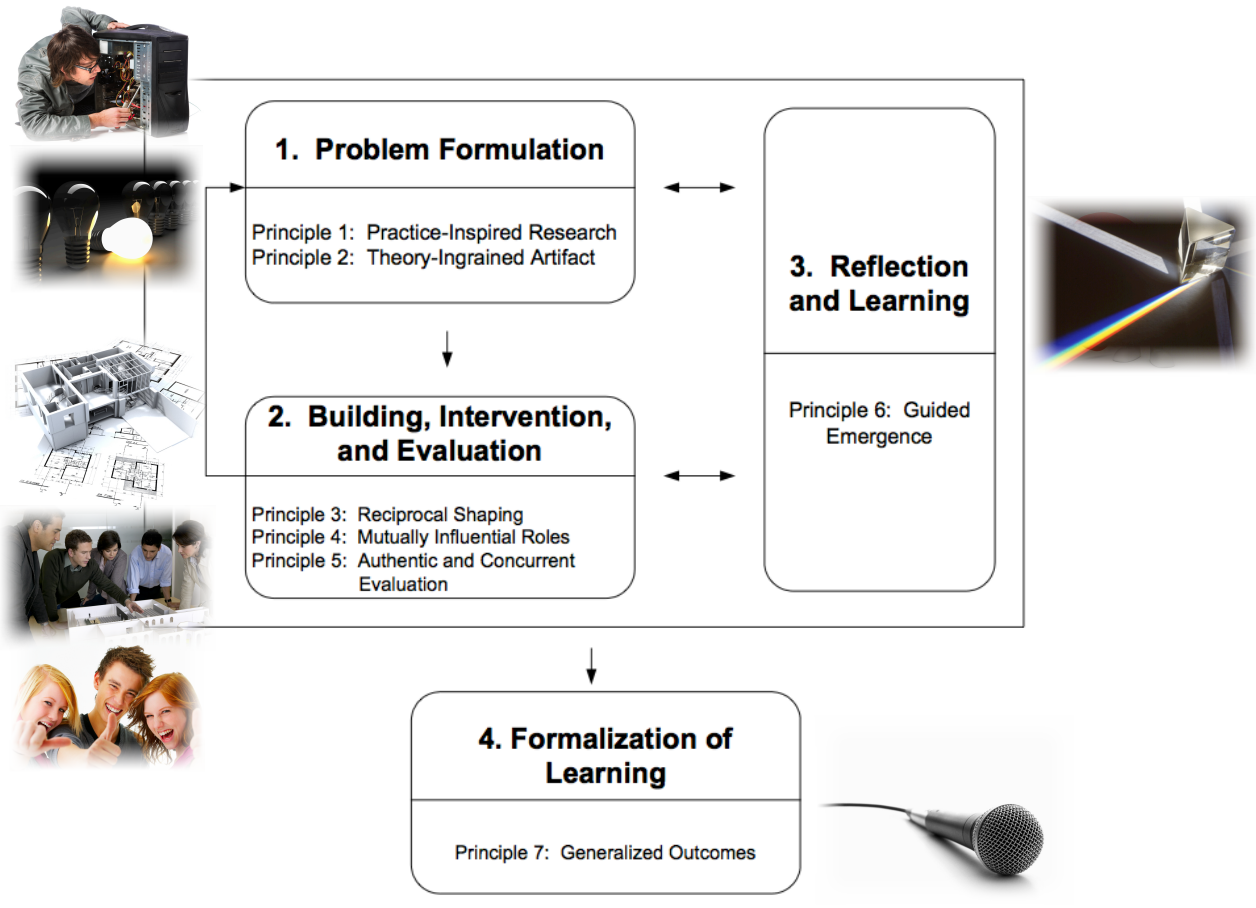


Figure 1: ADR method: stages and principles

need for a new design research method
the ADR method
ADR at Volvo

questions

how to re-interpret a published research to illustrate the features of ADR?

Competences Management System

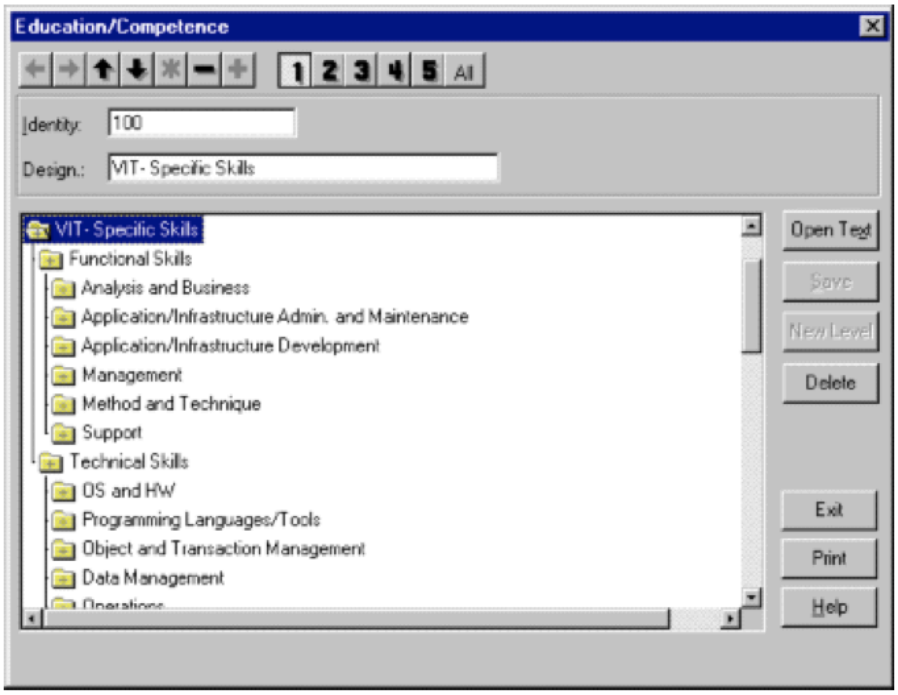


Figure 8: competence tree

1. problem formulation

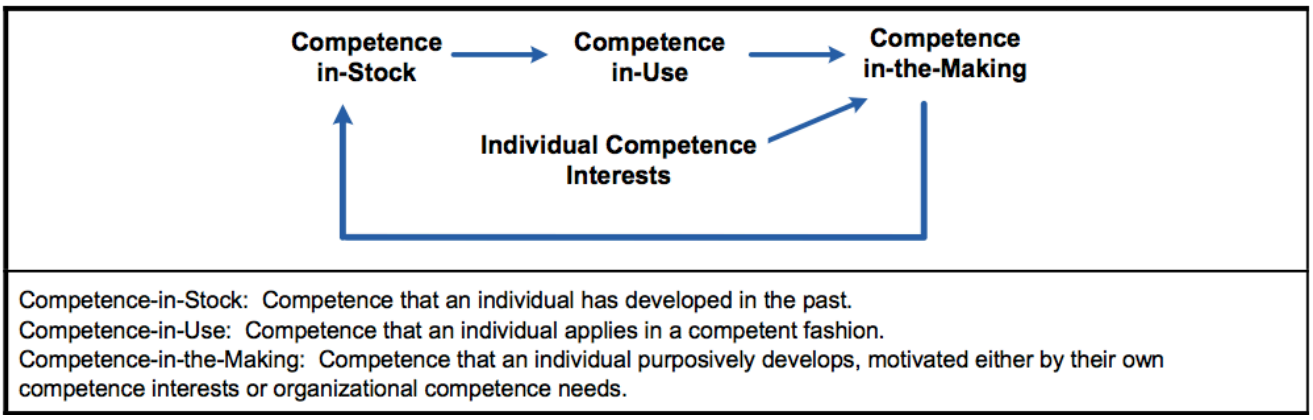
Table 1. Problems with Existing CMS	
Problem	**CMS in Use**
User isolation caused by hierarchically structured competence descriptions	• Restricted access to competence information to avoid internal recruiting • Individual users could only view their own competence descriptions • Knowledge sharing hampered
Emphasis on past competence by ignoring emerging and future competences	• Users hid competences to avoid unattractive assignments • Users overvalued competences to get attractive assignments • Users' competence development interests were unsupported
Rigid reporting style by allowing only analysis of predefined parameters	• Little support for strategic human resources planning • Inflexible reports

1

Table 1: Problems with Existing CMS

2. building, intervention and evaluation (BIE)

principles: User-Controlled Transparency Real-Time Capture Multi-Perspective Interest Integration



Competence-in-Stock: Competence that an individual has developed in the past.
Competence-in-Use: Competence that an individual applies in a competent fashion.
Competence-in-the-Making: Competence that an individual purposively develops, motivated either by their own competence interests or organizational competence needs.

2

Figure 9: The Competence Typology

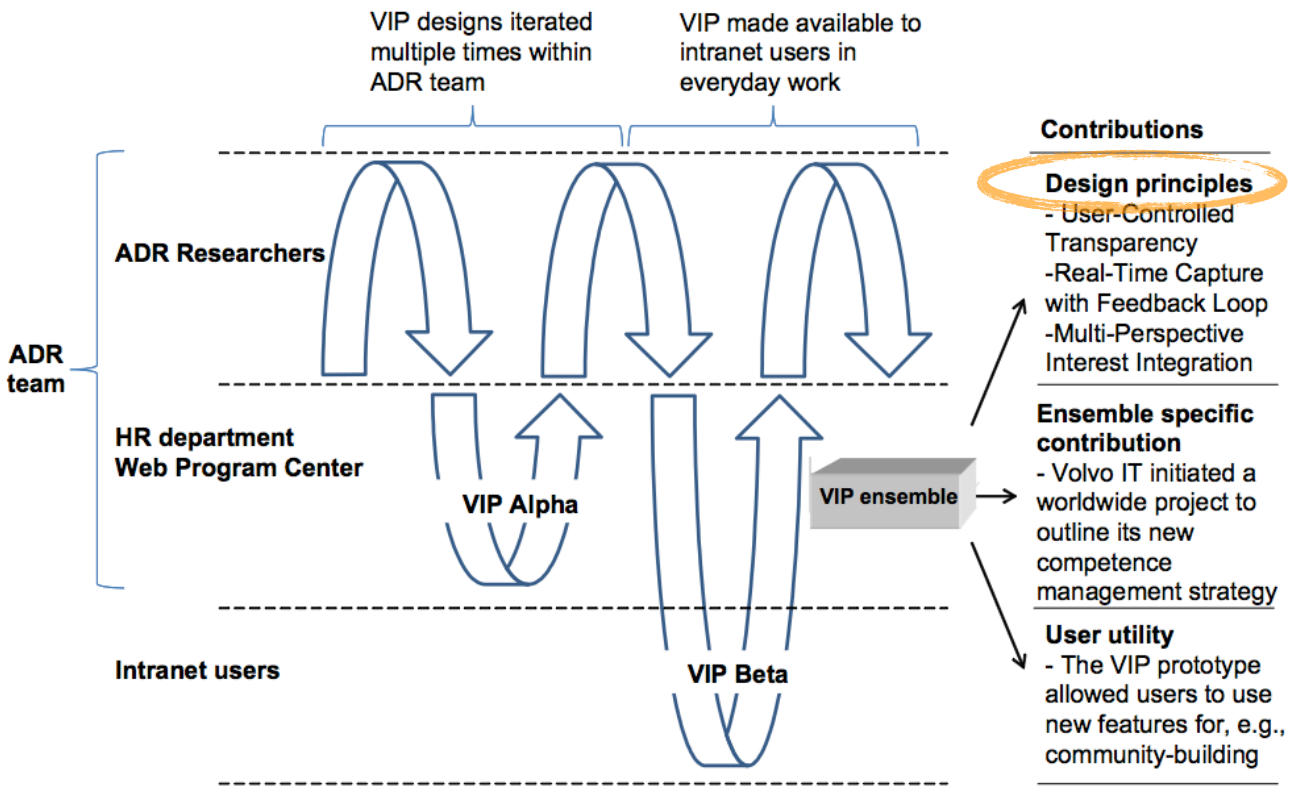
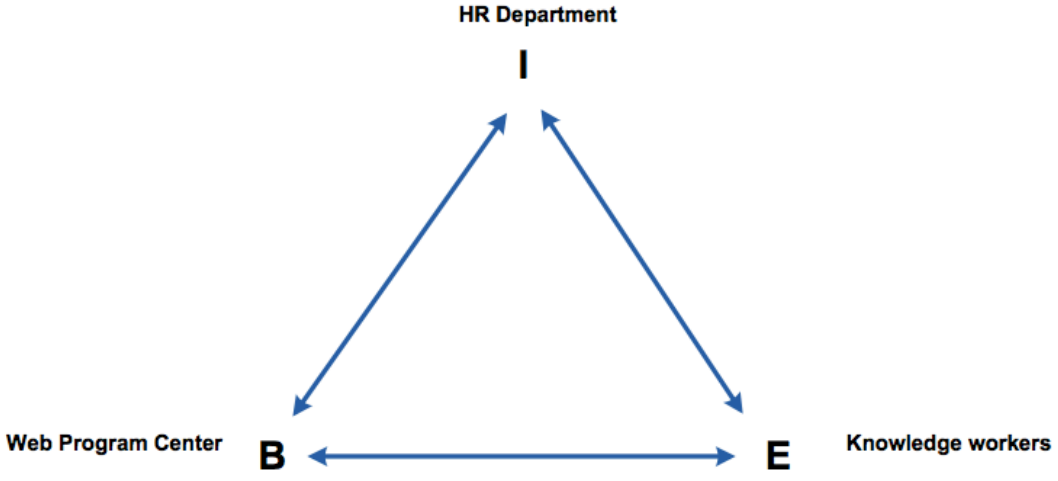


Figure 10: IT-Dominant BIE in the CMS Project at Volvo IT



B: Focal point of Building

- Senior Information Architect, main developer
- Technical linkages between web portals/recommender systems and CMS
- Relationship between information seeking behavior and competence representations
- New design agenda for CMS
- VIP as instantiation of new agenda
- CMS emerge as new competence area for Web Program Center

I: Focal point of Intervention

- HR managers including CMS area manager
- Reflections on low-tech competence systems failures
- Drawbacks of extant CMS
- Situating skill-based approach
- Projecting consequences of design principles
- VIP as medium of competence agenda dialogues
- Organizing new HR practices

E: Focal point of Evaluation

- End-users in different positions and across departments
- Identification of design flaws of extant CMS
- Generating competence profiles through everyday work
- Training VIP users for skill-based competence management
- Assessments of everyday VIP use for sustainable effects
- Seeking a CMS design path that caters for VIP lessons learned

Figure 12: Detailed View of BIE at Volvo IT

consequences

Design Principle	Consequences
Transparency	• Facilitated identification of colleagues at Volvo IT with mutual interests (anticipated) • Potential to hamper knowledge sharing when system indicates that no one else in the organization shares a particular interest (unanticipated)
Real-Time Capture	• Useful for tracking what people do on an everyday basis (anticipated) • Potential privacy violation when competences are tracked on the basis of system use (unanticipated)
Interest-Integration	• VIP was appreciated for implying a future orientation that would stimulate competence development (anticipated) • Risk that competent individuals get heavier workload when interests become visible to entire organization (unanticipated) • Little managerial incentives for promoting VIP use because of lack of performance criteria related to the tracking of competence-in-use and competence-in-the-making (unanticipated)

Table 2: Consequences of Building, Intervention, and Evaluation of VIP

3. reflection and learning

Design Principle	Description
User-Controlled Transparency	Competence-in-stock should be visible and accessible to the entire organization. *However, the control over which competence data is publicly displayed should rest with the user.*
Real-Time Capture *with Feedback Loop*	The system should track competence-in-use in real-time to generate competence data as it emerges through knowledge work in action. *However, users should be able to amend the system's representation of their competence.*
Multi-Perspective Interest Integration	Competence-in-the-making should be captured by accommodating individuals' interests as a proxy for the skills that they are motivated to develop. *However, the organization's perspective should also be incorporated into the system to address the potential tension between individuals' interests and the organization's needs.*

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4. formalization of learning

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Table 3: Consequences of Building, Intervention, and Evaluation of VIP

Stages and Principles		Artifact
Stage 1: Problem Formulation		
Principle 1: Practice-Inspired Research	Research was driven by the need for better IT support of competence management in knowledge-intensive organizations.	***Recognition***: Shortcomings of the existing CMS recognized as lacking the dynamism necessary for effective competence management.
Principle 2: Theory-Ingrained Artifact	The theory used was the skill-based model of competence and a competence typology.	
Stage 2: BIE		
Principle 3: Reciprocal Shaping	Poor data quality was expected to be an ongoing problem. Problems encountered were iteratively addressed and formulated as early design principles in collaboration with practitioners.	***Alpha Version***: The artifact conceived as a design idea; it should be reflective of the skill-based (not job-based) model of competence. ***Beta Version***: VIP prototype designed to implement skill-based competence and evaluate early design principles.
Principle 4: Mutually Influential Roles	The ADR team included researchers and practitioners in order to include theoretical, technical, and practical perspectives. The lead designer was an employee from Volvo IT who was also a Ph.D. student.	
Principle 5: Authentic and Concurrent Evaluation	VIP was first evaluated within the ADR team and then in the wider setting of end-users at Volvo IT.	
Stage 3: Reflection and Learning		
Principle 6: Guided Emergence	The ensemble nature of the VIP artifact was recognized. Furthermore, design elements for the IT component and changes to assumptions related to work practices emerged.	***Emerging Version and Realization***: New requirements for the VIP artifact based on results emerging in the BIE stage. A revised version of the initial design principles.
Stage 4: Formalization of Learning		
Principle 7: Generalized Outcomes	A set of design principles for CMS was articulated, positioning VIP as an instance.	***Ensemble Version***: An ensemble embodying the design principles and managerial policies for CMS use.

Table 4: Summary of the ADR Process in the CMS Project

ADR ...

a method for conducting research that seeks simultaneously to satisfy calls for

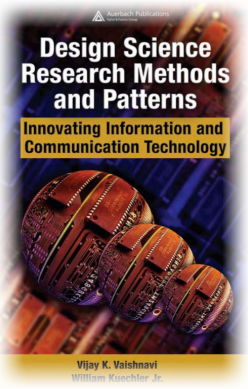
- theorizing the IT artifact and

- engaging in relevant research

next

Design Science Research Methods and Patterns

Vijay Vaishnavi and William Kuechler
Auerbach Publications (2008): 244 p.



chapter 5 *Using patterns to illuminate research practice*