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Designing solutions: practical relevance and theoretical contribution

Metodifestivaali 28 August 2019

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Contents

- In this session, we present a set of research approaches typically used in industrial engineering and management (IEM)
- We explain our understanding of the concepts inductive case research, design science, action research, constructive research approach and interventionist research
- … followed by examples of their applications in the IEM research field
- The similarities and interfaces of these approaches will be elaborated, particularly from the perspectives of practical relevance and theoretical contribution

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From inductive case research to design science …

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Hypothetico-deductive large-sample study	Inductive case study
Motivation	Motivation
Body of knowledge	Specify a priori constructs
Theory building	Select cases
Formulate hypotheses	Craft instruments
Craft instruments	Enter the field
Sampling and data collection	Within- and cross-case analysis
Reliability and validity	Shaping hypotheses
Test of hypotheses	Enfolding literature
Discussion	Reaching closure

Inductive versus deductive logic of reasoning

1. Research logic

2. Data	Inductive	Deductive
Qualitative		
Quantitative		

Induction =
Building theories from data

Deduction =
Testing theories with data

Sampling
- Pooling: statistical characteristics
- Theoretical sampling and replication: each case is an independent example

Source: K.M. Eisenhardt 1988

When to use inductive case research?

- New phenomenon
- Conflict in the existing theories
- Gap in the existing theories
- Existing theories are inadequate
- E.g., decision making in high velocity environments (Eisenhardt, 1988) or supply chain management in highly uncertain and fast growing telecommunications industry (Heikkilä, 2002)

- Small percentage of all research
- Research process might unfold in unexpected ways
- May be very time and resource consuming!

Example:
From Supply to Demand Chain Management: Efficiency and Customer Satisfaction

Source: Heikkilä 2002

Research question

What is the architecture of a well-performing supply chain in a young, fast growing industry selling systems with varying hardware and software content to industrial customers?

Unit of analysis:
Supply chain for building cellular networks

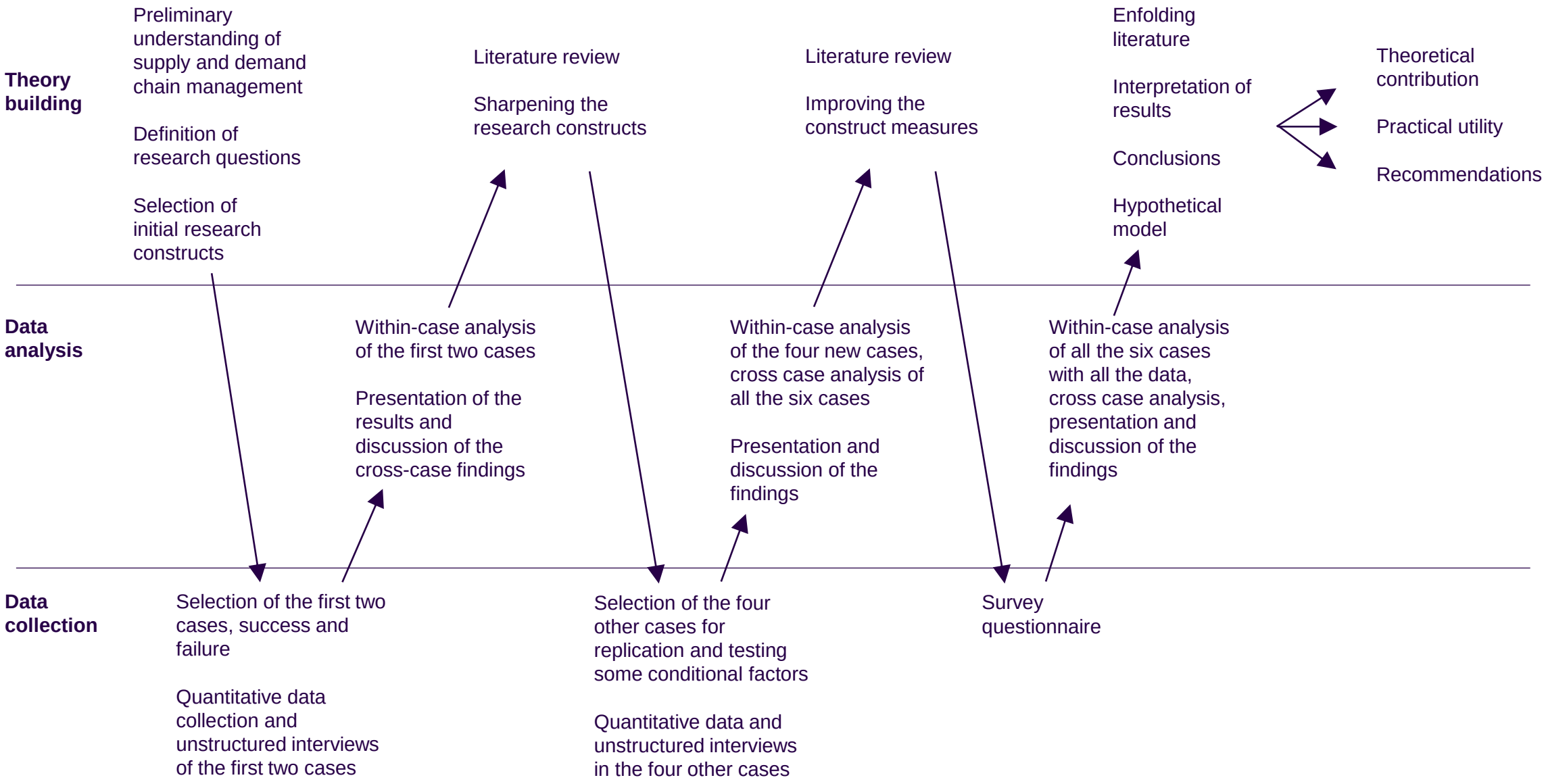
(3) Supplier's factory:
- Manufacturing and delivering base stations for the customer's cellular network

(2) Supplier's country organization:
- Combined account, project and logistics organizations that were responsible for serving the customer

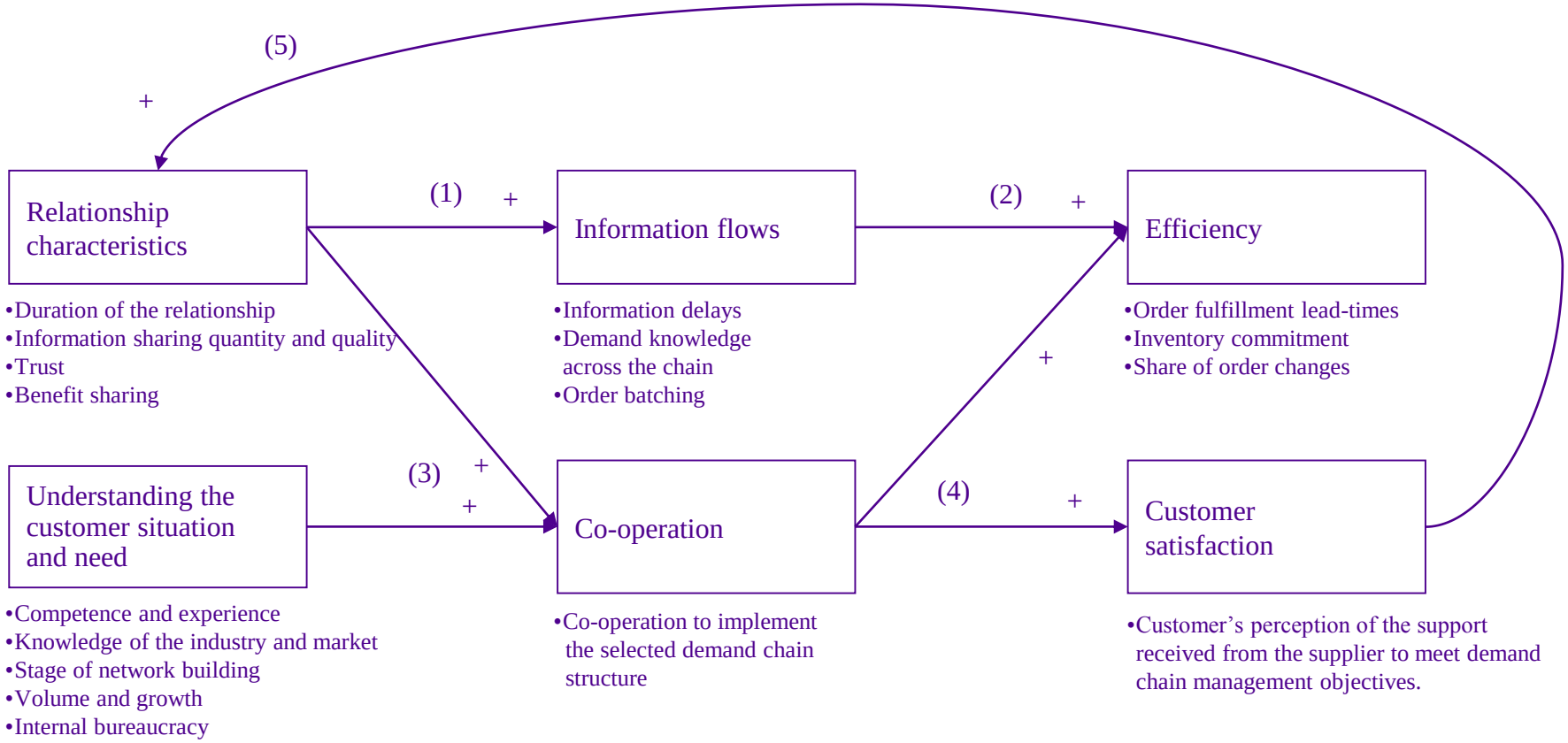
(1) Customer - Telecommunications operator:
- Organizational units that were responsible for building and operating the cellular network

Research constructs	Data collection
Supply chain structure • Members of the supply chain • Information and material flows between the members • Sources of delays and distortions in the information flows	Interviews • 27 supplier informants • 8 customer informants Database of 605 order-to-delivery cycles
Customer – supplier relationship • Commitment to future interaction • Relation-specific assets and interdependence • Communication • Trust	Interviews Survey • 27 supplier respondents • 19 customer respondents • Overall response rate 73%
Supply chain performance • Customer satisfaction (effectiveness) • Efficiency	Survey Database of order-to-delivery cycles interviews

Research process



Results and solution: Hypotheses and their operationalization



Source: Heikkilä 2002

The research findings are summarized in the demand chain management model presented in the previous slide.
The model consists of the following five propositions emerging from the research of the six cases in the cellular network industry:

Proposition 1. Good relationship characteristics contribute to reliable information flows.

Proposition 2. Reliable information flows contribute to high efficiency.

Proposition 3. Understanding the customer situation and need and good relationship characteristics contribute to co-operation between the customer and supplier.

Proposition 4. Good co-operation in implementing demand chain improvement contributes to high efficiency and high customer satisfaction.

Proposition 5. High customer satisfaction contributes to good relationship characteristics.

Source: Heikkilä 2002

Enfolding literature

- Different from related literature
- Same as distant literature, e.g. biology, complexity, chaos theory, psychology

Contrast with existing thinking: Why are you different?

Source: K.M. Eisenhardt 1988

Tests for the quality of case study designs

- *Construct validity:* establishing correct operational measures for the concepts being studied
- *Internal validity:* establishing a causal relationship, whereby certain conditions are shown to lead to other conditions, as distinguished from spurious relationships
- *External validity:* establishing the domain to which a study's findings can be generalized
- *Reliability:* demonstrating that the operations of the study—such as the data collection procedures—can be repeated

Source: Yin 2009

Strengths and weaknesses

Potential strengths

- Likelihood of generating novel theory
- Testable theory with measurable constructs and provable hypotheses
- Empirically valid theory

Potential weaknesses

- Overly complex or modest theory
- Narrow and idiosyncratic theory
- Theory which is not yet tested

Source: Eisenhardt 1989

From inductive case research towards design science …

	Exploratory research – design science	Explanatory research – theoretical science
The phenomenon	”Artificial phenomena” have to be created by the researcher	”Out there”
Data	Created, collected and analyzed	Collected and analyzed
End product	Solving of a problem	Explanatory theory, prediction
Knowledge interest	Pragmatic	Cognitive/theoretical
Disciplinary basis	Engineering, fundamentally multidisciplinary	Natural and social science, primarily unidisciplinary

Source: Holmström et al. 2009

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Design science: key characteristics and the process

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Metodifestivaali: Designing solutions: practical relevance and theoretical contribution 28.8.2019

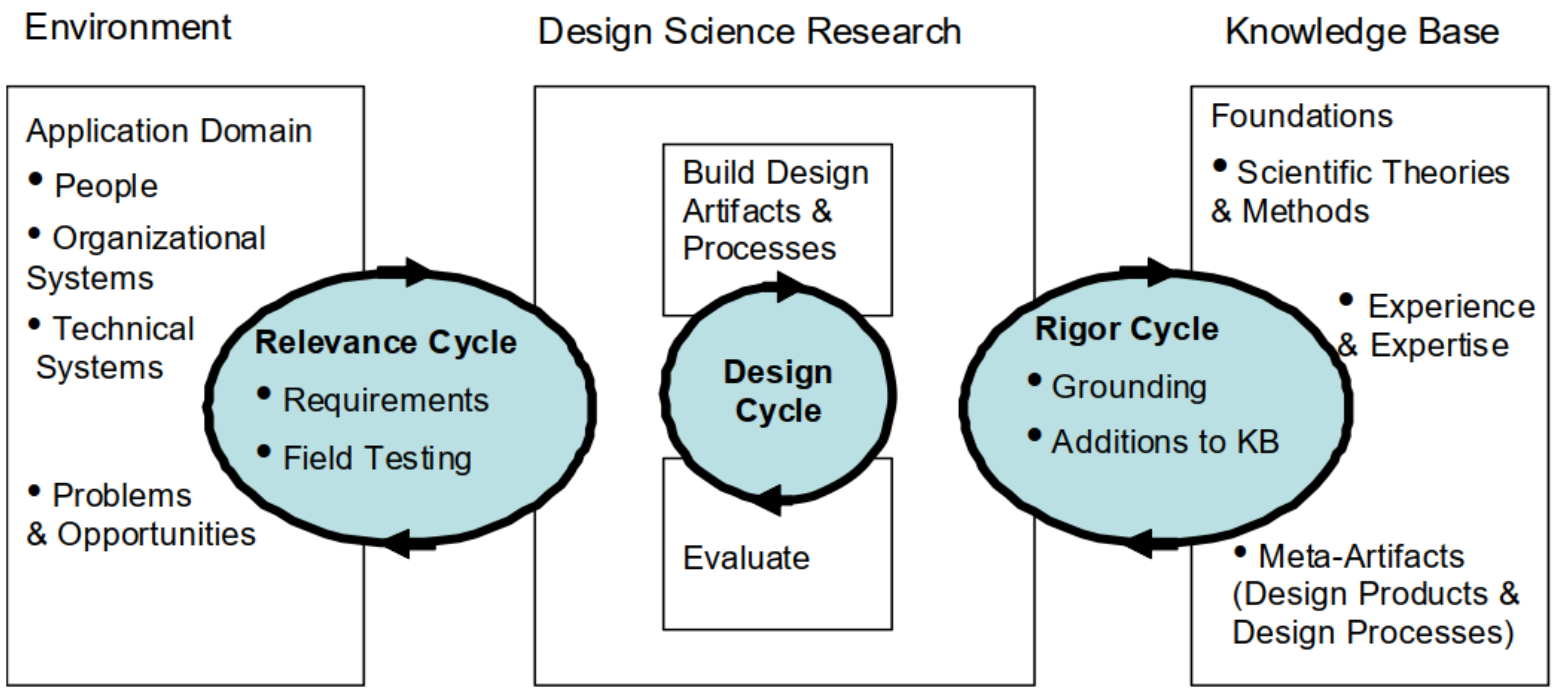
Contents

- Characteristics of design science and constructive research
- Processes of design science and constructive research
- Case: performance management maturity model design

One classification of science (Van Aken, 2004)

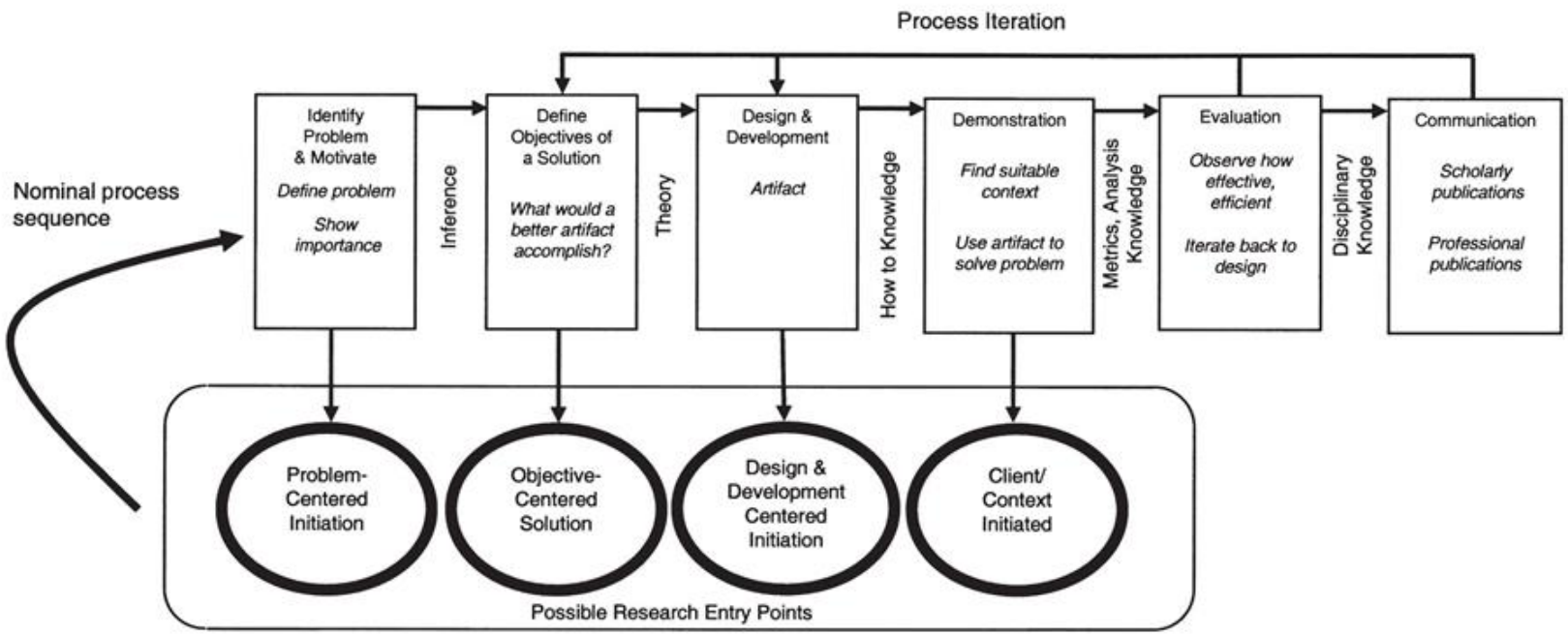
- Formal Science
  - E.g. philosophy, mathematics
  - mission is to build systems of propositions whose main test is their internal logical consistency
- Explanatory Science
  - e.g. the natural sciences and major sections oft he social sciences
  - mission is to describe, explain and possibly predict observable phenomena
- **Design Science**
  - **e.g. the engineering sciences and medical science**
  - **mission is to develop knowledge for the design and realization of artefacts, i.e. to solve problems**

Specific characteristics of design science



Hevner, 2007

Design science process



Peffers et al., 2007

Specific characteristics of constructive research (adapted from Kasanen, Lukka, Siitonen 1991)

- Applied empirical research which aims at creating new solutions and innovations
- Construction: solution, framework, method, process, tool which solves a specific pre-determined problem.
- Normative research: gives guidelines on how to approach/solve a specific problem
- Novelty testing of the new solution is important, specific tests of constructive research
  - Weak market test: are decision-makers ready to utilize the construction?
  - Strong market test: is the performance of the examined unit better after applying the construction?

Practical relevance of the problem

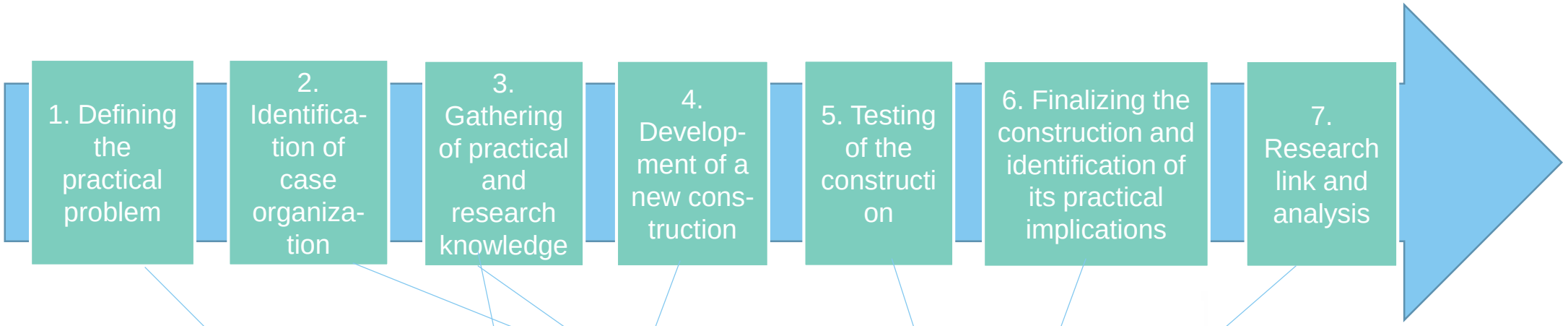
Research support for the construction

Construction: solution to a problem

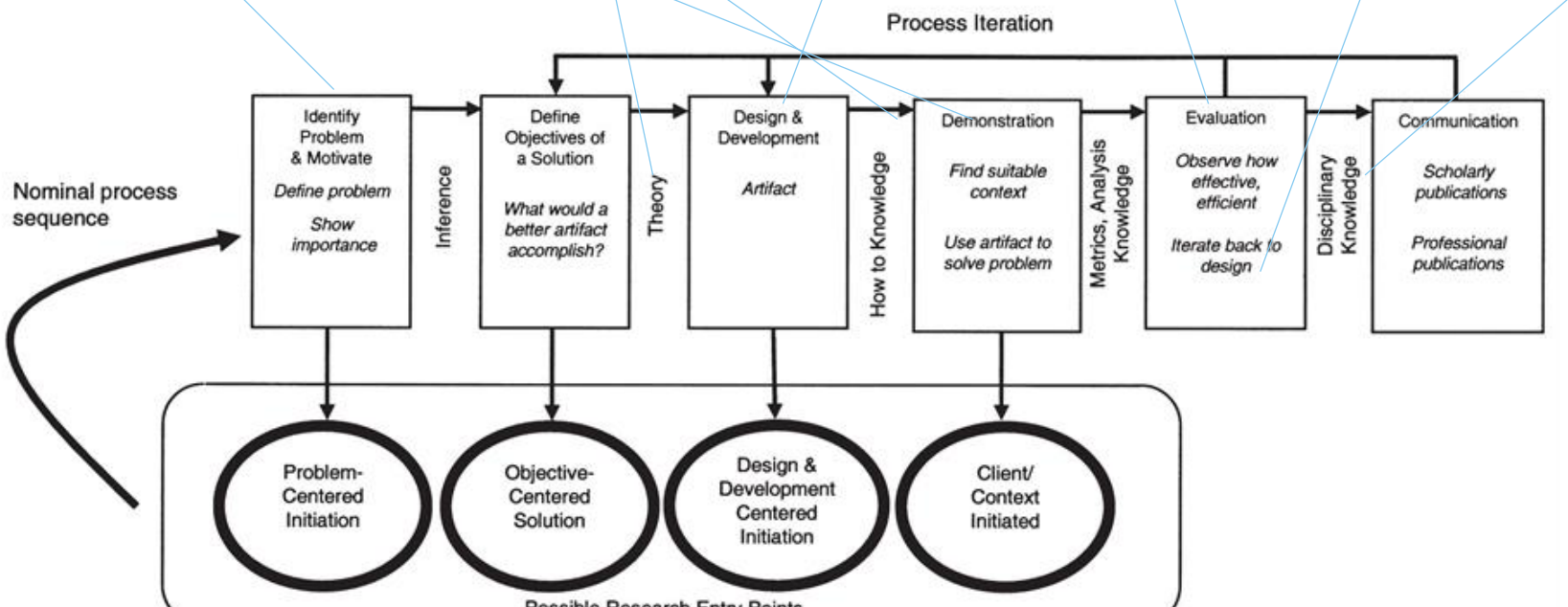
Testing of the construction in practice

Theoretical novelty of the construction

Similarities in the processes?



Constructive research:
Kasanen, Lukka, Siitonen 1991



Design science:
Hevner, 2007

Design science example

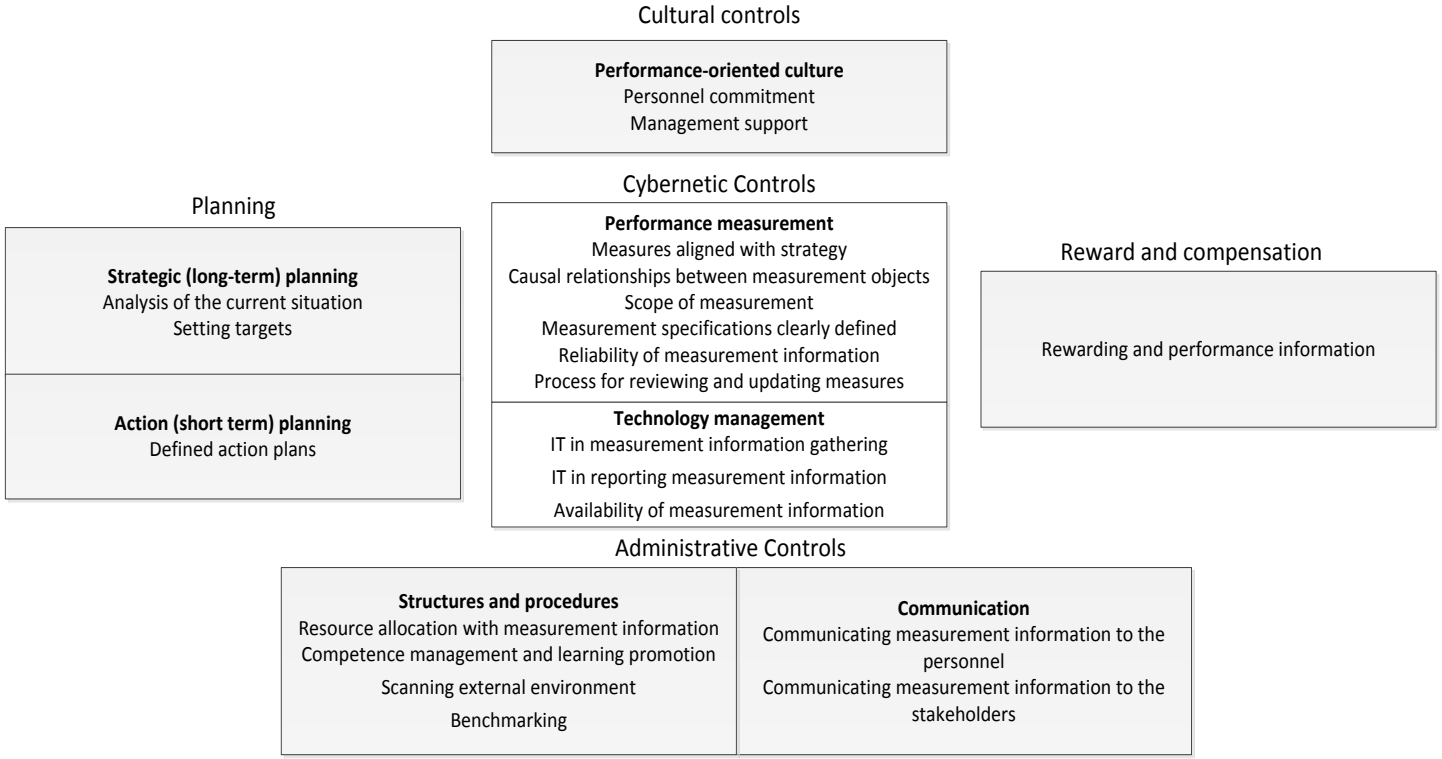
Performance management maturity model development (Jääskeläinen and Roitto, 2015)

Introduction to performance management maturity model design

- Performance measurement: quantifying the efficiency and effectiveness of action for managerial purposes
- Research and practice raised the need to understand better why the full potential of performance measurement is not realized in practice
  - Performance measurement techniques and systems
  - Supportive structures such as organizational culture
  - Use of performance measurement information
- Companies needed a tool to
  - Identify and prioritize their development needs
  - To benchmark with other companies

Solution - framework

- Evaluation variables were identified from the appropriate literature (12 studies)
- Variables were classified into the perspectives of the management control systems as package model by Malmi and Brown (2008)



Solution: evaluation instrument

- Self-evaluation survey addressed to managers and administrative experts in the area of performance measurement, management accounting and information systems
- Survey instrument was designed with maturity levels describing various ways of operating
- Written descriptions of practices:
  - Literature on performance measurement and management as well as consultancy-originated models formed the basis for the level 1 and level 4 practices
  - Researchers' intuition was needed especially in the levels 2 and 3

Level	Communicate PM Results to Relevant Stakeholders
Level 1	Measurement results are not communicated to stakeholders
Level 2	Measurement results are communicated to stakeholders in a random manner
Level 3	Measurement results are communicated to stakeholders with a case-specific report
Level 4	Measurement results are communicated to stakeholders with a pre-defined and structured report

Testing

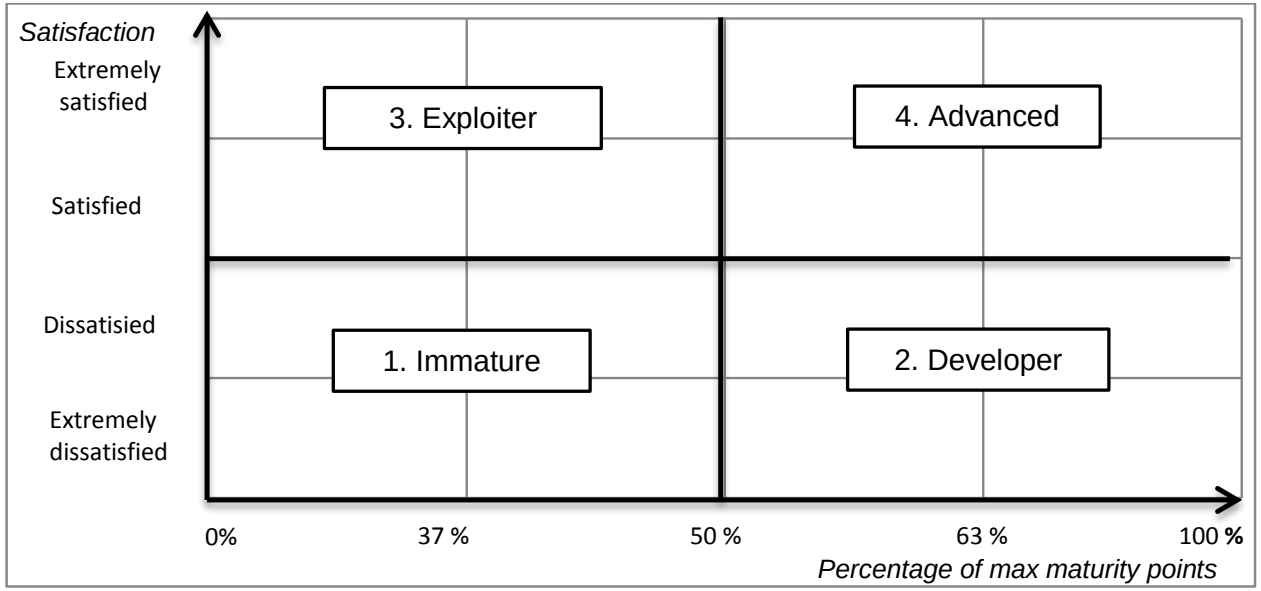
- Gathering of empirical data for testing and further development of the solution
  - 271 replies from 119 public and private organizations representing were collected
  - Response rate of 22%
  - Basic statistical numbers (averages, standard deviations) were used in defining the maturity profiles
  - Analysis of variance was used in studying the differences between the profiles
    - These differences were used to form instructions on how to improve from one profile to another

Evaluation

	Factor	Indicator	Result	Status
Academic rigor	Validity	Comments made by respondents	PM scope not criticized, mostly positive comments	Moderate
	Validity	Relation to maturity points with financial performance	Adjusted $R^2 < 0.001$; $p = 0.323$	Inconclusive
	Validity	Relation to maturity points with satisfaction rate	Adjusted $R^2 = 0.437$; $p < 0.001$	Good
	Reliability	Cronbach's α in model's perspectives	All α's between 0.58 and 0.76	Moderate
	Reliability	Differences in organization's answers (standard deviation)	Unable to confirm ground reason	Inconclusive
Practical relevance	Relevance	Answering to the end of the questions after starting	98 %	Excellent
	Relevance	Answering percentage (for personal e-mails)	22 %	Good
	Practicality	Answering time	Median 11 minutes, mode 8 minutes	Good

Solution: maturity profiles

Position	Maturity Score (% max maturity score)		Position	Satisfaction rate
1st tier	0-37 %		1st tier	2- less than 4 (extremely dissatisfied)
2nd tier	37-50 % (1 standard deviation from average)		2nd tier	4 – 5 (dissatisfied)
3rd tier	50-63 % (1 standard deviation from average)		3rd tier	more than 5 – 6 (satisfied)
4th tier	63-100 %		4th tier	more than 6 (extremely satisfied)



Profile Number	1.	2.	3.	4.
Number of respondents	115 respondents (42%)	31 respondents (11%)	14 respondents (5%)	111 respondents (41%)

Conclusion

- There are several research approaches with similar characteristics to design science
- No established process model or guide for design science but still some common aspects
  - Development of solutions
  - Testing or evaluation
  - Rigor/relevance examination
  - Iterative characteristics

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Interventionist research (IVR) and action research (AR)

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What constitutes a theory contribution? (Whetten 1989)

- What?
  - Are all factors included?
  - Are some of them irrelevant?
- How?
  - How are the factors related?
- Why?
  - Underlying psychological, social or economical factors
  - Valuable presentation
- Who, where, when?
  - Circumstances, context

- ***IVR or AR are not 'special cases'***, they could yield interesting results on all the tough questions:
  - What's new?
  - *So what?*
  - *Why so?*
  - *Well done?*
  - *Why now?*
  - *Who cares?*

Interventionist research – basic concepts

- ***Action research*** seeks to develop the organization at hand, and contributes *therefore/at the same time* to the theory development
- **Interventions** are a part of an action research **process**, in various forms, with various consequences; tool implementations, new concepts, new ways of thinking
- May combine **qualitative and quantitative research**
- Research is driven by the *action* that drives the *contribution, not at all ”less scientific”*

Justification for interventionist research (Suomala et al. 2014, Lyly-Yrjänäinen et al. 2017)

- For understanfing social phenomena, we need a real access to ’action’ (from *etic* (outside) to *emic* (inside) perspective and back…)
- Access to
  - interesting environments
  - right informants
  - valid and reliable data
  - topical phenomena & issues
- *Enables the formulation of novel and relevant research questions*

What can qualify as ’intervention’ in research?

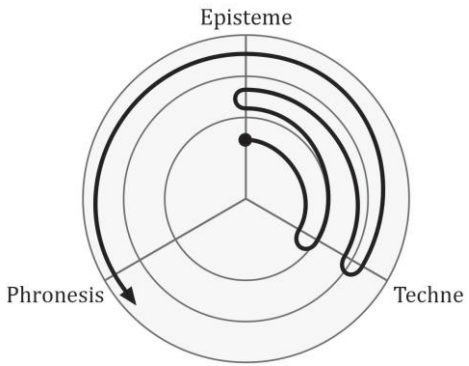
- Strong and weak
- …and many variations in between

- Being present (in occasion)
- Making comments
- Participating in organization’s work
- Importing one’s own expertise into organization
- Facilitating change processes
- …

Interventionist research – A balanced approach towards relevance

(Lukka & Suomala 2014, societal impacts, Lyly-Yrjänäinen et al. 2017)

- The observation and claim of Flyvbjerg (2001) (based on Aristotle): there are several intellectual virtues that researchers can pay attention to:
  - Episteme: how and why things are as they are
  - Techne: how to make things work
  - Phronesis: how to cope with particular situations, involving power and value-related deliberations



- The first two have been mainly considered in action research (AR) and interventionist research (IVR)
- Phronetic science (PSS) has a practical, yet simultaneously value-sensitive agenda, leading to “social science that matters” → new domains!
- Flyvbjerg regards PSS as applying the virtue of techne “with head on it” (making it thereby phronetic)

Example 1: Boundary subject in accounting development

(Laine et al. 2016, Qualitative Research in Accounting and Management)

- Researcher is an actor in the research process
- The concepts and content of action research (on accounting development) fit naturally well in many practical contexts
- ”Boundary subjects and boundary objects in accounting prototyping”
  - Accounting development through prototyping involves several actors and integrates (functional) knowledge of the actors
  - Especially in PD, accounting is very challenging and practice immature
  - In PD, boundary objects are used to help communcation
  - If the researcher is an active change agent, he/she can be as a temporary boundary subject and enhance accounting development
  - Acting as a boundary subject precedes several phases of practical development and provides access to theoretically interesting data

Example 1: Boundary subject in accounting development

(Laine et al. 2016, Qualitative Research in Accounting and Management)

Roles present in meetings	*Different people*	*Percentage*
Production	11	41 %
PD project personnel	4	15 %
Another division of the company	3	11 %
After sales	2	7 %
Finance/Accounting	2	7 %
Sourcing	2	7 %
PD program management	1	4 %
Product management (product line sales)	1	4 %
Research personnel	1	4 %
TOTAL	27	100 %

- Action research (2012-2013) included working in the assembly line, sending ”greetings” to other managers, designing accounting prototypes, facilitating discussion about them etc.

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Example 1: Boundary subject in accounting development

(Laine et al. 2016, Qualitative Research in Accounting and Management)

cost management center

From whom the "greetings" are from / *To whom the "greetings" are intended*							
Function	*R&D*	*Sourcing & Operative purchases*	*Production*	*Product line*	*Project*	*After sales*	*Accounting*
R&D		**Concern** of subcontractor's quality after the prototype machines have been built.	**Concern** of manufacturing "current" and "new" machine generations on the same production line.	**Question** about production ramp-up and ramp-down schedule. **Concern** of killing the "current" machine generation. **Wish** that there are volume options but not everything possible.	**Wish** that responsibilities are clarified regarding interfaces and the product family.		
Sourcing & Operative purchases	**Wish** to have a change log about which component replaces what. **Wish** to limit changes to make it possible for subcontractors to deliver.		**Wish** to get support for make-or-buy decisions regarding the prototype machine.	**Wish** to plan and estimate ramp-up and ramp-down. Wish to increase the volume as quickly as possible.	**Wish** to commit to decisions that have been made. **Wish** to give estimates to support sourcing work.	**Wish** not to offer every single component as an available spare part but as larger packages.	**Question** about how to quantify e.g., postponement and scale benefits in monetary terms.
Production	**Concern** of lacking a "common language" because products are designed for manufacturing and assembly and the product structure fixes production organizing.	**Wish** for comprehensive cost-consciousness, not only prices.	**Wish** to construct prototype machines carefully and taking the time needed (internal communication between production line assembly and protype assembly).	**Reality check** that estimates are the basis for production planning. **Reality check** that the "current" and "new" generations will not fit into the same production line, making ramp-down a must. **Wish** for quick ramp-up and not going back and forth.	**Wish** for communication about the R&D project. **Wish** for clear responsibilities. **Wish** for ramp-down decisions (not assembly three generations at the same time in production, i.e. the "previous" "current" and "new" generations.		**Wish** for pressuring stakeholders about costs. **Concern** of the cost of waiting. **Wish** for cost-consciousness.
Product line	**Wish** for available engineering resources when problems with the "new" generation occur. **Question** about the prices for new optional features.	**Wish** for prices for spare part components.	**Question** about delivery lead times that can be promised to the customer. **Question** of production volumes that would be undesirable for longer periods of time.				**Question** of whether one can find optimal scenarios about the minimun amount of machines on a production line, the maximum amount of machnines on an assembly cell, or a volume range that would be undesirable. **Wish** for bringing up different viewpoints. **Wish** for reasoning. **Wish** for common language. **Wish** for showing the indirect costs.
Project				**Wish** for plans to kill the "current" machine generation. **Question** more specifically about what is ramped-down.			
After sales	**Wish** for a controlled cycle of making design releases. **Wish** for preparing for faults that need to be corrected. **Wish** for platform thinking. **Wish** for not too much customer-specific designs.			**Wish** for software road maps. **Wish** for centralized product support. **Wish** for training for those that operate in the front line.			
Accounting	**Question** about the development of component items (in total) and structures.	**Questions** about the costs of component items (in total). **Question** about the costs of component items (in total). **Question** about the essential component items.	**Question** about learning curves. **Question** about scheduling changes in production.	**Wish** for estimates for production ramp-up and ramp-down.	**Wish** for a definition for production ramp-up.	**Question** about the possible benefits from the "new" machine generation in after sales.	**Wish** for product costs (self-reflection).

Reality check that estimates are the basis for production planning. **Reality check** that the "current" and "new" generations will not fit into the same production line, making ramp-down a must. **Wish** for quick ramp-up and not going back and forth.

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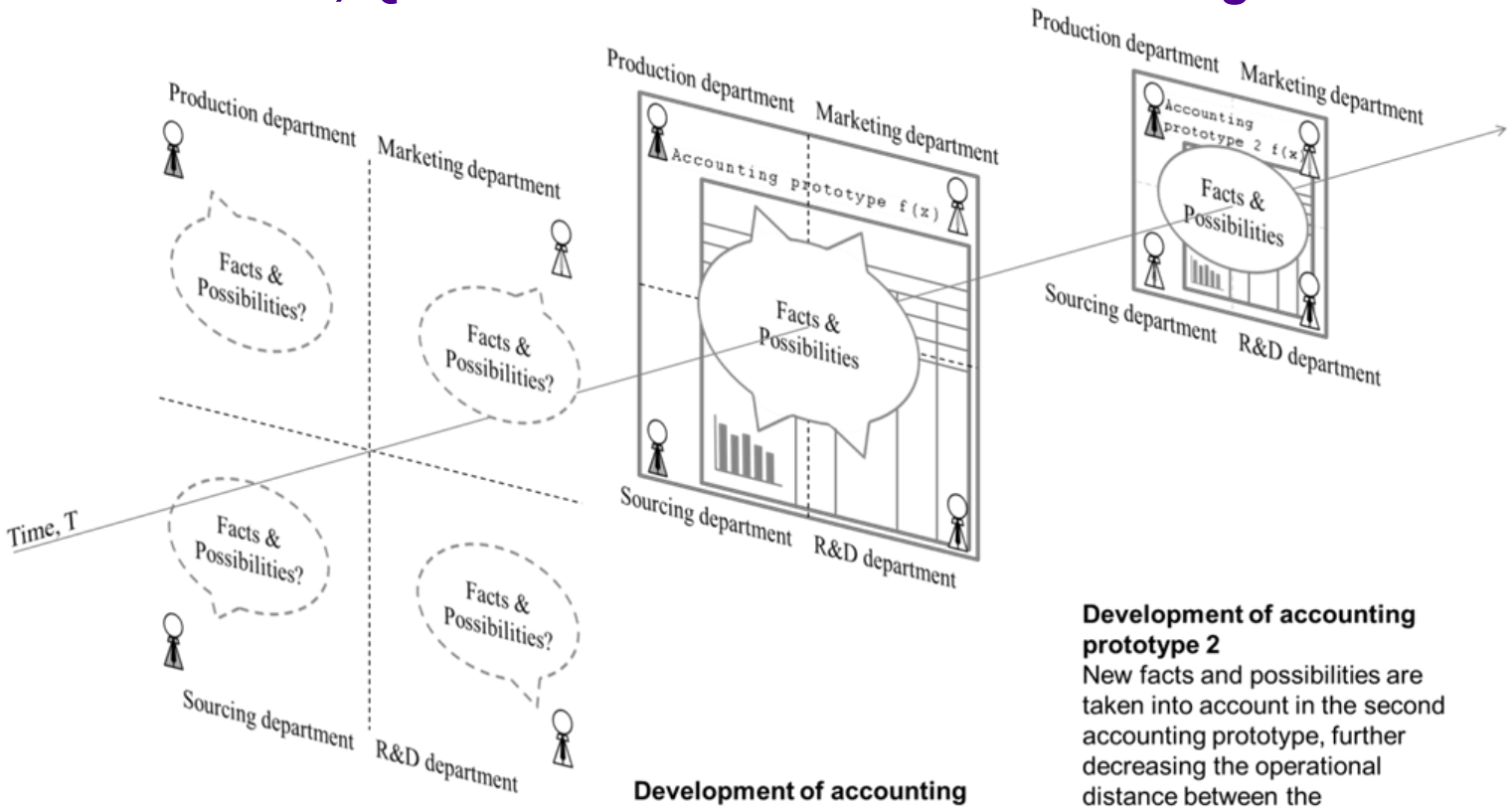
Example 1: Boundary subject in accounting development

(Laine et al. 2016, Qualitative Research in Accounting and Management)

cost
management
center



The need for knowledge integration between different R&D stakeholders

→

Development of accounting prototype 1
Actors communicate their facts and possibilities to other departments during accounting prototype development, decreasing the operational distance between the departments.

→

Development of accounting prototype 2
New facts and possibilities are taken into account in the second accounting prototype, further decreasing the operational distance between the departments.

Less emphasis is now placed on active communication, since actors' facts and possibilities are already comprehensively included in the second accounting prototype.

Example 1: Boundary subject in accounting development

(Laine et al. 2016, Qualitative Research in Accounting and Management)

- Action research approach and the interventions enabled access to several theoretically interesting phenomena *(researcher as actor):*
  - The viewpoint (subjective reality) of the different actors could have been interviewed → *interventions were required to send greeting about challenges*
  - The initial challenge, lack of accounting support in ramp-up, could have been identified with interviews → *interventions enabled discussions and elaborations about the ramp-up management in general in the company*
  - The first accounting prototype for the ramp-up management could have been designed based on the literature → *interventions were needed to understand the actual use context and the dynamics in designing and adopting new practices in such a context*

- The theoretical contribution is still about the process, how accounting facts are constructed & communicated and how to build a shared understanding and enhance communication through accounting development

Overview of action research (AR) and interventionist research (IVR)

- **What is a solution in the interventionist research?**
  - The **domain** of the solution can be many different things: supporting societal transformation, increasing competitiveness/profitability/customer satisfaction
  - The solution **('tool')** can be many different things, a calculation, a device, a software, a process model/practice, management training, ...
- **What kinds of issues could ensure relevance in the interventionist research?**
  - The research question needs to address a real-life challenge
  - The research question is thus d/refined during the research process
- **How is theoretical novelty enabled and measured?**
  - Using *tool/method theories* in the interventions enable contributions to *domain theories* (and maybe to the tool/method theories, cf. Lukka & Vinnari 2014)
  - Contribution is identified and measured in the usual way, all kinds of contributions are possible *via* interventionist research

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Questions, answers and reflections

Questions

- What is a solution?
- What kinds of issues could ensure relevance?
- How is theoretical novelty enabled and measured?