

Systems Engineering Research Methods

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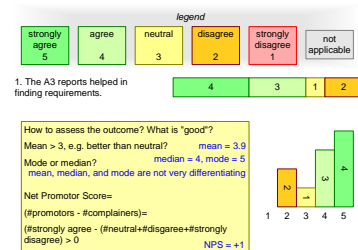
Abstract

Research in System Engineering research inherently addresses a mix of technological issues in relation to business, process, organization, and people aspects. We show an inventory of research methods for research done in the “field”, e.g. in industry or similar organization.

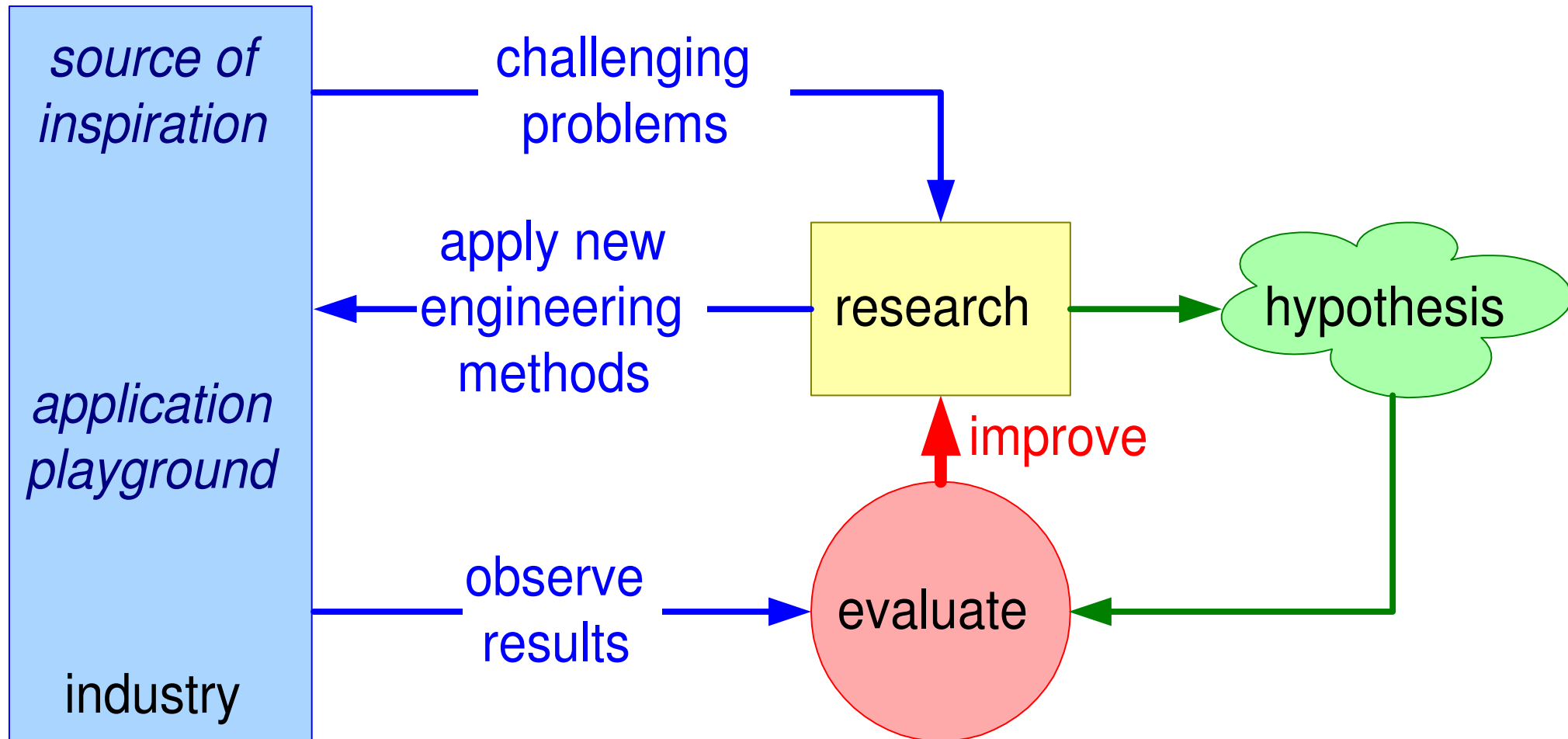
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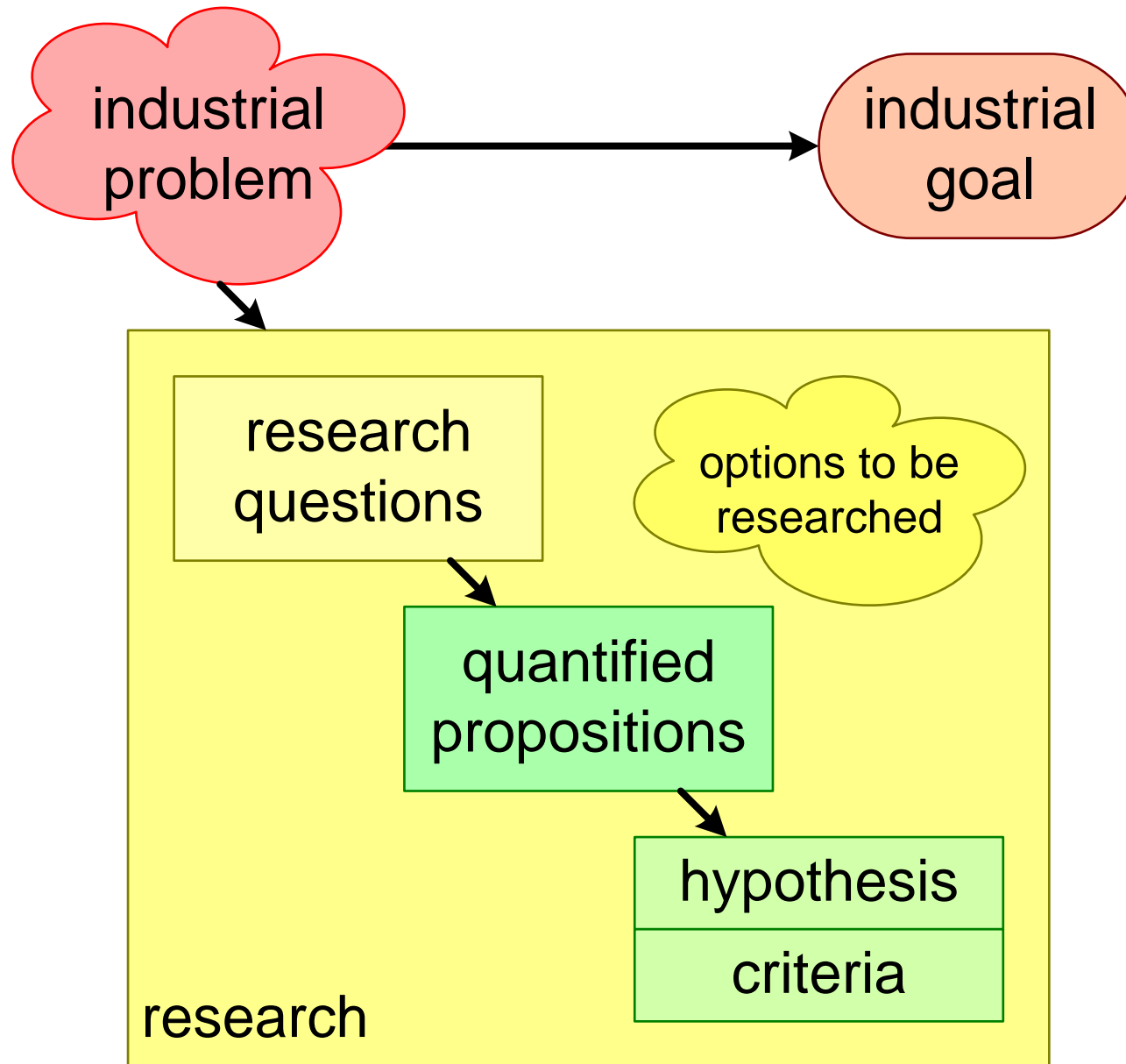
Action Research or Industry-as-Laboratory



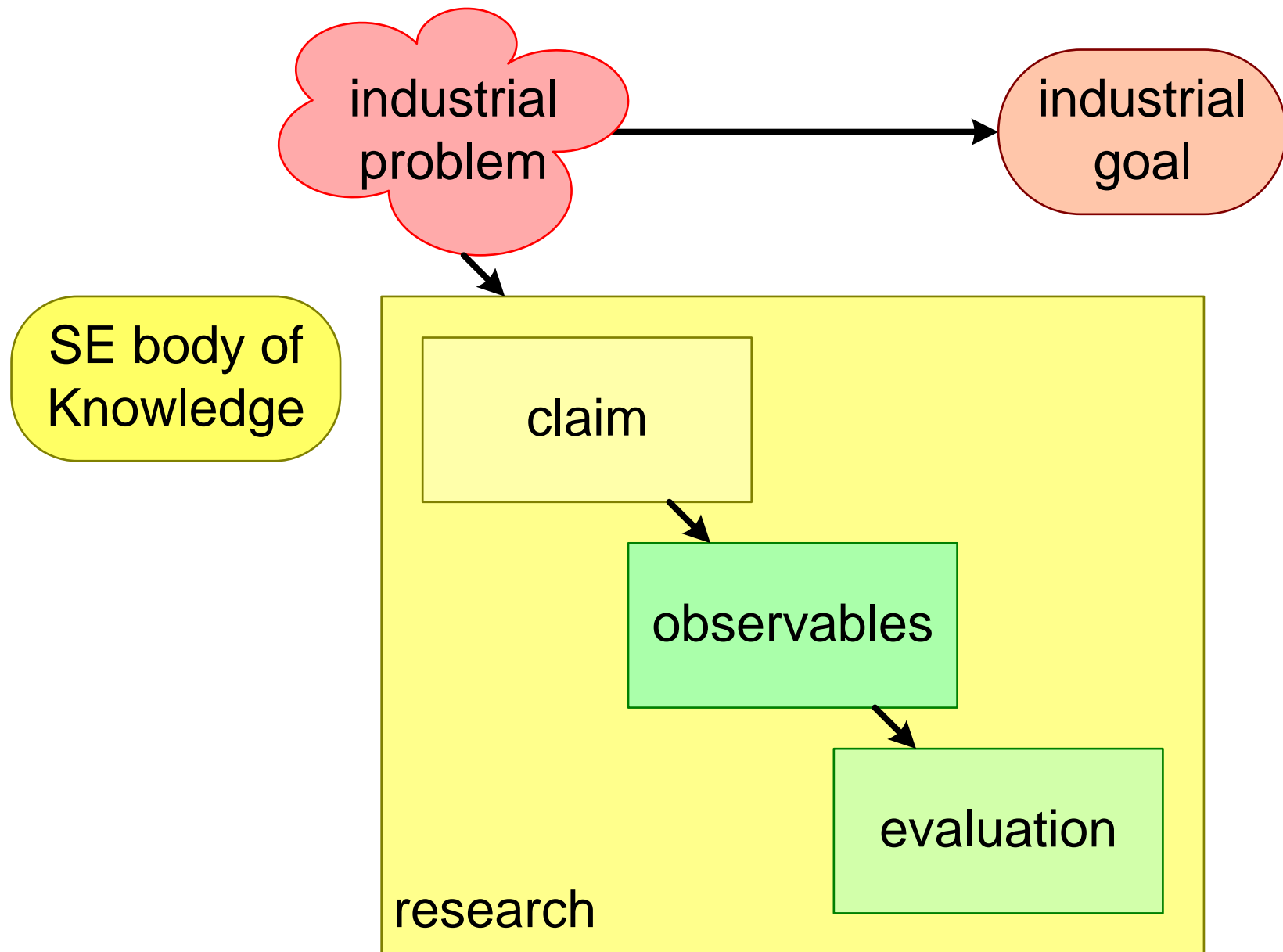
Systems Engineer vs Researchers

	<i>systems engineer</i>	<i>researcher</i>
normal work	elicit needs, specify, design, analyze, integrate, test	observe, experiment, argue, evaluate, write
attitude	explain, educate, sell	question everything, proof opposite

Logical Order of Research



Simplified Order for Master Project



Step 1: Formulate Claim

Claim: What benefits will your proposed improvements bring?

"Application of requirements traceability matrix
will reduce changes after the definition phase significantly"

Be specific (what, who, when, how much, ...)

Does the claim address the original problem?

Is the claim realistic?

Do the benefits justify the research effort?

Do the benefits relate to the right driver?

20% or 80%
would be better

better predictability of delivery
earlier delivery
better quality of delivery
less cost or effort

Step 2: Identify Observables

Observables: What observations or measurements will provide evidence for your claim?

number of changes after definition phase in past projects without method

number of changes after definition phase in current project with method

Be specific (what, who, when, how much, ...)

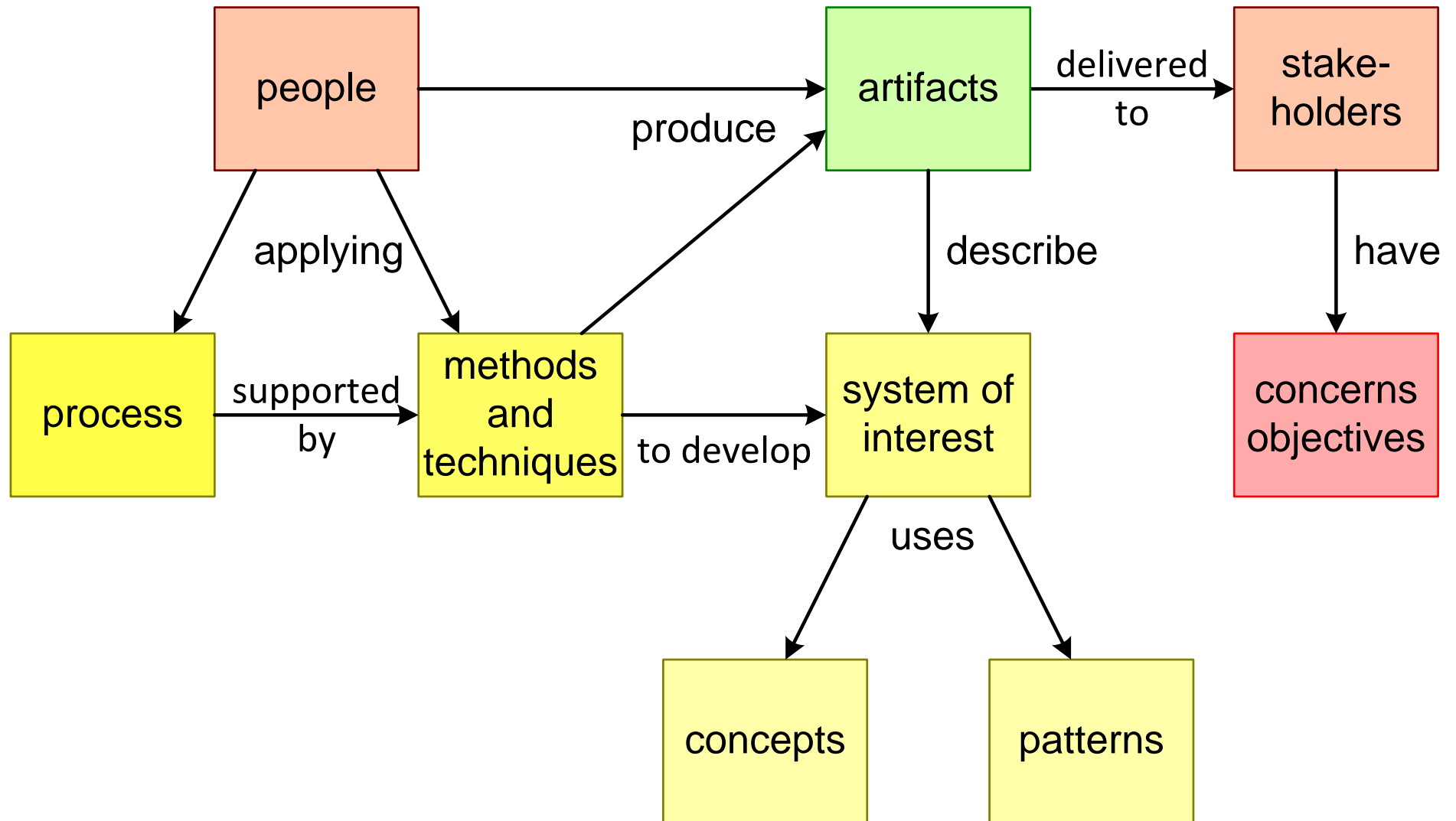
Do the observations relate to the claim?

Can the observations be made during the research period?

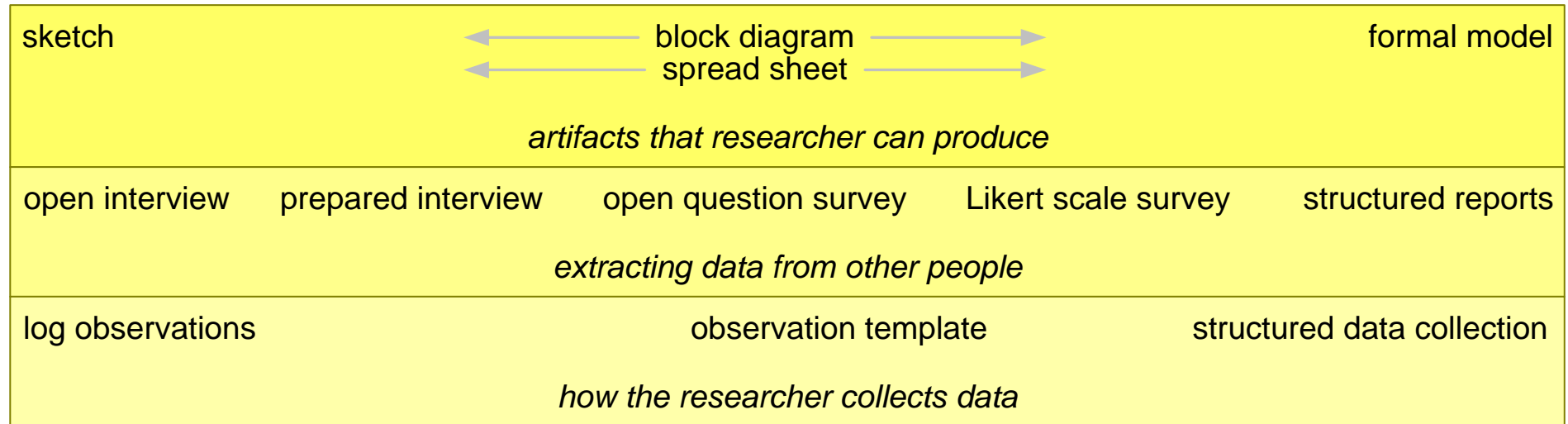
How accurate and objective are the observations?

Observe/measure the initial state before changing "zero measurement"

What to Research; Observe Context



Spectra of Research Methods



← free format

standardized format →

- . free representation
- . no formal definition
- + supports
 - discovery
 - exploration
- difficult for
 - analysis
 - comparison
 - aggregation

- . standardized data
- . formalized definition
- + supports
 - analysis
 - comparison
 - aggregation
- might
 - restrict inputs
 - affect observation

Research Logbook

Word or PowerPoint file
take notes continuously!

date/time

what

how

why

when

where

who

references, e.g. URLs; make electronic copy of any relevant material

all "raw" data, e.g. submitted questionnaires

all intermediate data, e.g. spread sheets with version numbers and dates

Example Observation Template

Session attributes – date (year/month/day)	
Kind of session:	Communicate information/status
	Sell a idea/concept
	Brainstorming/generate ideas
	Decision making
	Solve/discuss problem(s)/issue(s)
	Planning
	KPI/Performance/Action log
	Team building/training
	Presentation
Physical location of session:	Defined meeting room
	Colleague own office
	In the factory – “on the shop floor”
Planned session or not:	Planned
	Unplanned
A3 purpose:	
A3 name/link:	
A3 usage/iteration number:	
A3 usage time with stakeholders:	
Number of participants:	
Did everyone understand the A3:	
Did it answer some of the stakeholders questions:	
Create any new questions/concerns:	
Models changed/added:	
Stakeholder participation:	
Prefer A3 instead of A4:	
Observations/recordings:	

from Master Project by Espen Polanscak

Survey with Likert Scale

Questionnaire

1. The A3 reports helped in finding requirements.

strongly agree

agree

neutral

disagree

strongly disagree

not applicable

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Presentation data

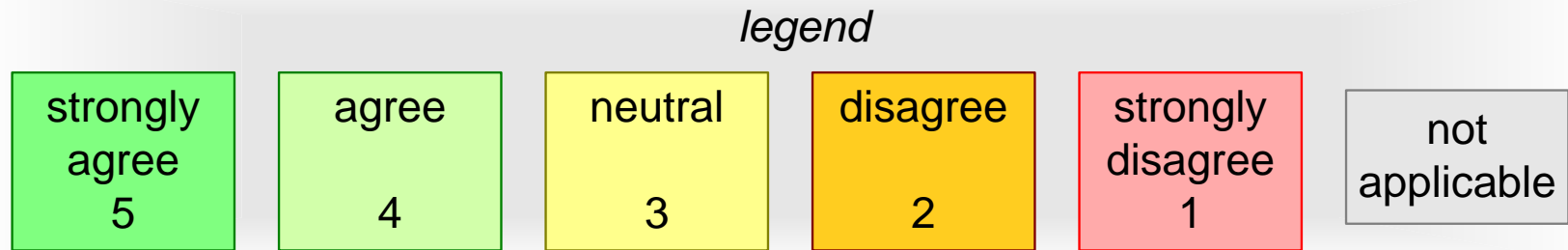
legend



1. The A3 reports helped in finding requirements.



Evaluation of Surveys



1. The A3 reports helped in finding requirements.



How to assess the outcome? What is "good"?

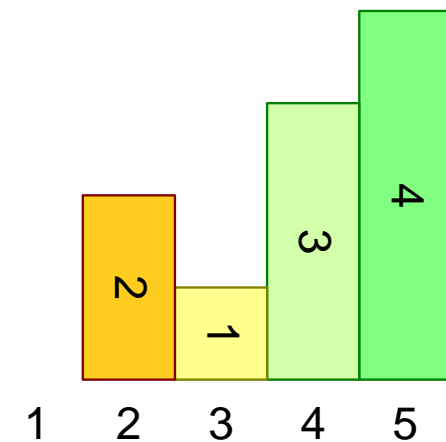
Mean > 3, e.g. better than neutral? mean = 3.9

Mode or median? median = 4, mode = 5
mean, median, and mode are not very differentiating

Net Promotor Score=

(#promoters - #complainers)=

(#strongly agree - (#neutral+#disagree+#strongly disagree) > 0 NPS = +1



References

Action research:

<http://cadres.pepperdine.edu/ccar/define.html>

O'Brien, R. 1998. *An Overview of the Methodological Approach of Action Research*. University of Toronto http://www.web.ca/robrien/papers/arfinal.html#_edn2

Industry-as-Laboratory:

Colin Potts. *Software-engineering research revisited*. IEEE Software, Vol. 10, No. 5:19–28, September/October 1993.

Gerrit Muller and W. P. Maurice Heemels, *Five Years of Multi-Disciplinary Academic and Industrial Research: Lessons Learned*; CSER 2007 in Hoboken NJ

Likert Scale:

Jamieson, Susan. (2004). *Likert scales: how to (ab)use them*. Medical Education. <http://xa.yimg.com/kq/groups/18751725/128169439/name/1LikertScales.pdf>

Net Promotor Score:

Frederich Reichheld *The One Number You Need to Grow*, Harvard Business Review 2003, <http://hbr.org/2003/12/the-one-number-you-need-to-grow/ar/1>

Keiningham, T, L. Aksoy, L. Cooil, B. Andreassen, T, W. (2008). *Net Promoter, Recommendations, and Business Performance: A Clarification on Morgan and Rego*. Marketing Science. Vol.27, No. 3, May-June 2008, pp. 531-532. <http://www2.owen.vanderbilt.edu/bruce.cooil/Documents/Publications/2008--Marketing%20Science.pdf>