Design Research: Three Illustrations

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Operational Research and Design: – Developing the Dialogue

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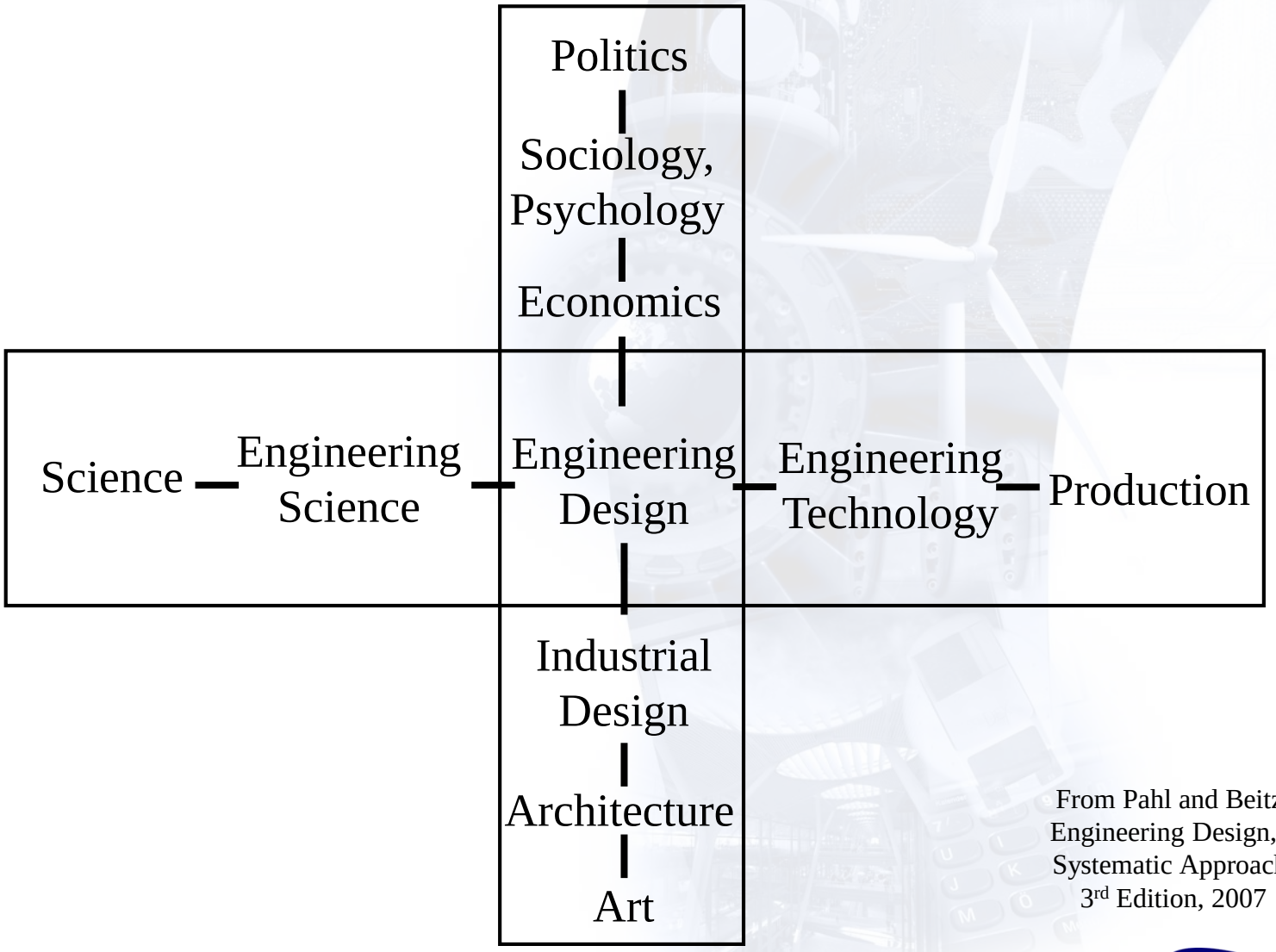
Overview – diversity in topic and approach

Topics:

- The multiple perspectives of design research
- A mapping of perspectives to facets
- Some observations on design research methodology
- Three examples:
  - method and tool development
  - the study of individual designers
  - the study of design teams
- Concluding remarks

The design eco-system



From Pahl and Beitz, Engineering Design, a Systematic Approach, 3rd Edition, 2007

DS consolidated topics

In 2009 the DS introduced a consolidated topic list to be used for ICED conferences (with % papers in each ICED)

	2009	2011	2013
• Design Processes	14	12	14
• Design Theory/Research Methodology	11	9	7
• Design Organisation and Management	9	9	10
• Product, Service and System Design	8	11	14
• Design Methods and Tools	23	20	13
• Design for X, design to X	8	8	9
• Design Information and Knowledge	9	12	12
• Human Behaviour in Design	9	12	17
• Design Education and Lifelong Learning	8	7	4

DS consolidated topics

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Facets of design research

- Time – from very short episodes to activities taking many months
- Product life cycle phase – from specification to end of life
- People – from individuals to large teams and communities
- Activities and issues – from single to large numbers
- Artefact focus from features to complex interconnected systems
- The degree of originality from variant design to radical disruptive innovation
- The abstraction used in design and research representations
- The research approach, including observation, survey and interview, modelling and simulation, experimental application of method/tool etc.

How can we study design?

- We can ask about work, opinions and experiences
  - Questionnaires and interviews
- We can observe people at work
  - Ethnography, observation
- We can get them to tell us what they are doing and why
  - Protocol analysis
- We can get them to make records from their work
  - Diary studies
- We can study what they produce
  - Logbook and document studies
- We can do experiments with them
  - Laboratory studies, Blessing-Chakrabarti
- We can do case studies of well-known examples

Facets of design research

- A comparison between the responses of experienced and inexperienced designers to visual stimuli in idea generation.

  People: individuals; Time: minutes; Activities: single; Parts: single/small assemblies; Life-cycle stage: early concept; Originality: original; Method: observation

- Design of forgings for fatigue resistance

  Life cycle stage: embodiment/detail; Parts: features/single parts; Activities: single; Abstraction: medium; Time: hours; People: individuals; Originality: adaptive; Method: literature review, experimental application of method

Facets of design research

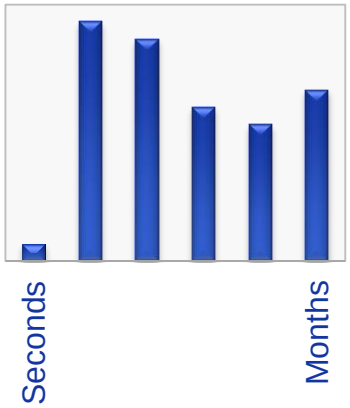
- Reducing automobile supplier design time through process simulation

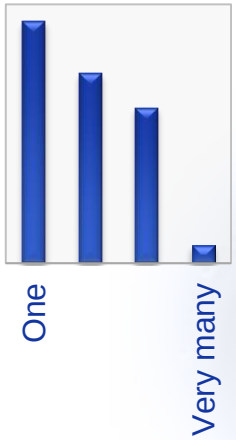
  Time: weeks/months; Activities: many; People: interconnected teams; Parts: small assemblies; Abstraction: high; Life-cycle stages: specification to detail; Originality: adaptive; Method: modelling and simulation

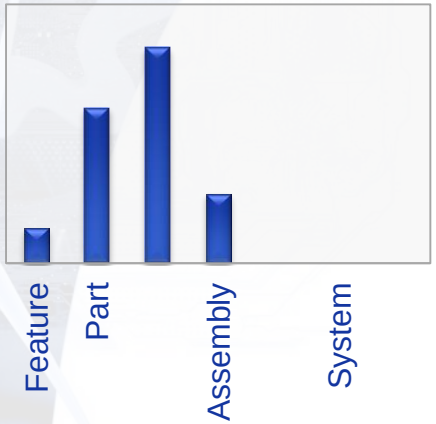
- The management of design responses to environmental legislative change in the consumer electronics industry

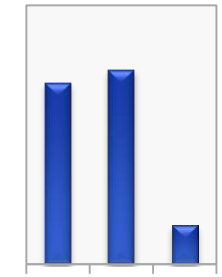
  Time: months; Activities: range; People: interconnected teams; Parts: small assemblies; Abstraction: low; Life-cycle stage: specification to detail; Originality: adaptive; Method: interview and questionnaire

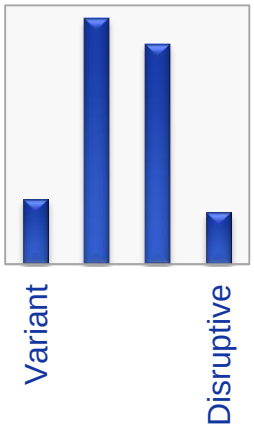
ICED09: Human Behaviour in Design

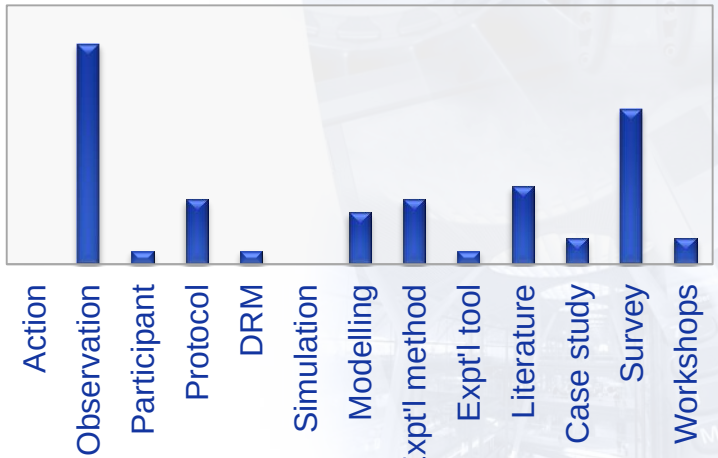


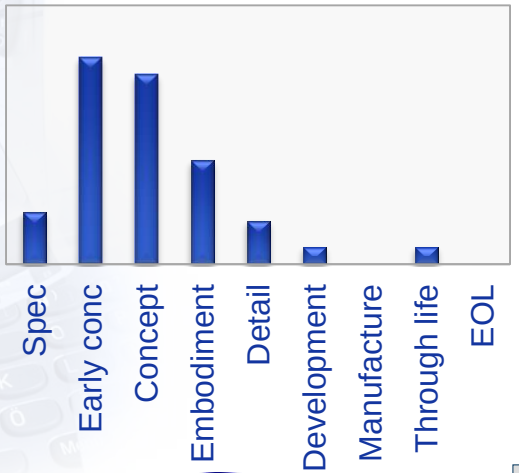




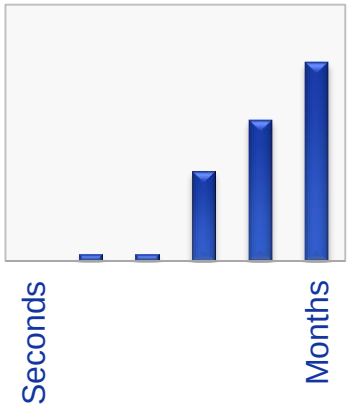


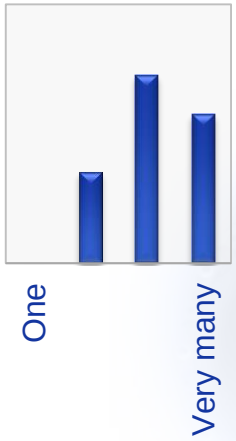


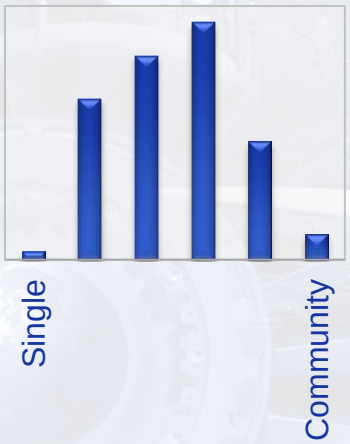


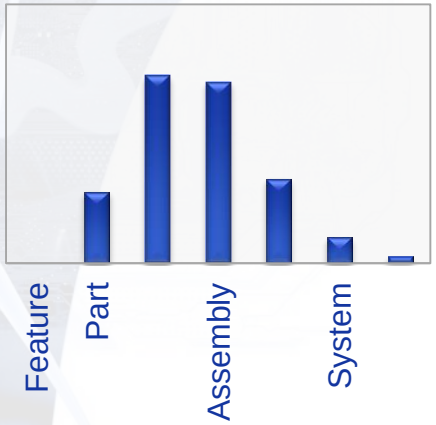


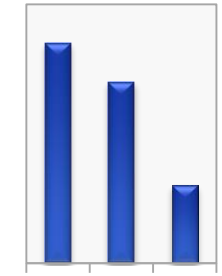
ICED09: Design Organisation and Management

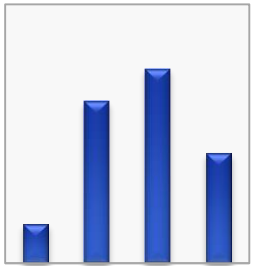


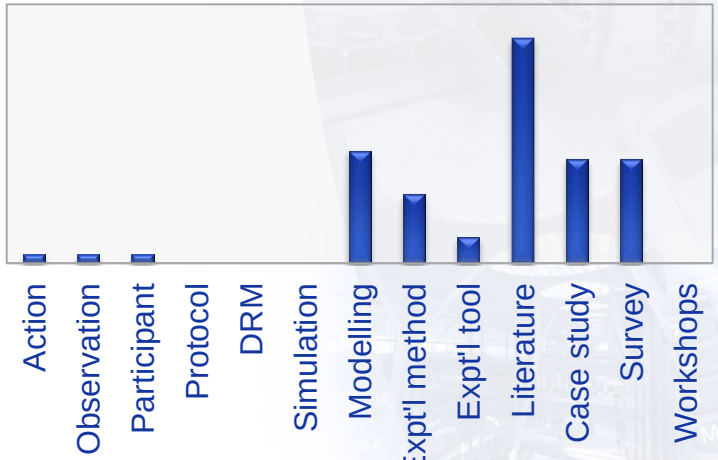


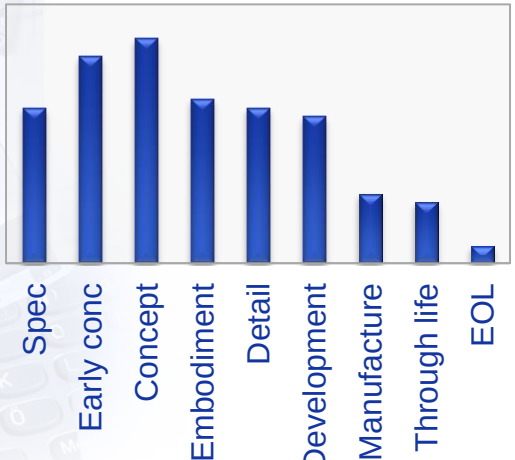






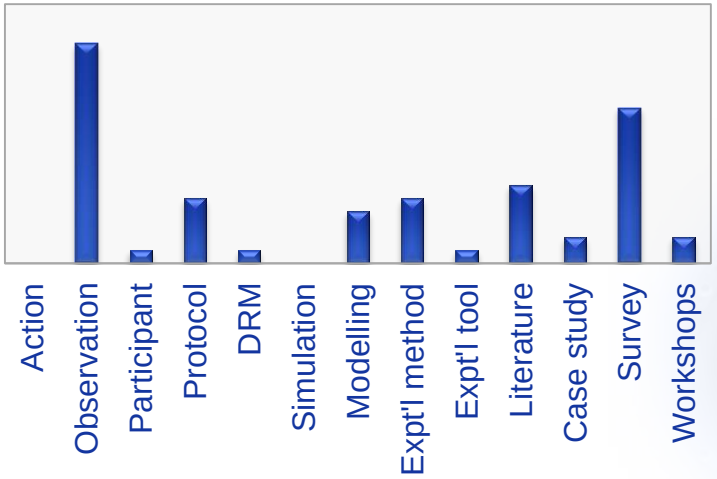




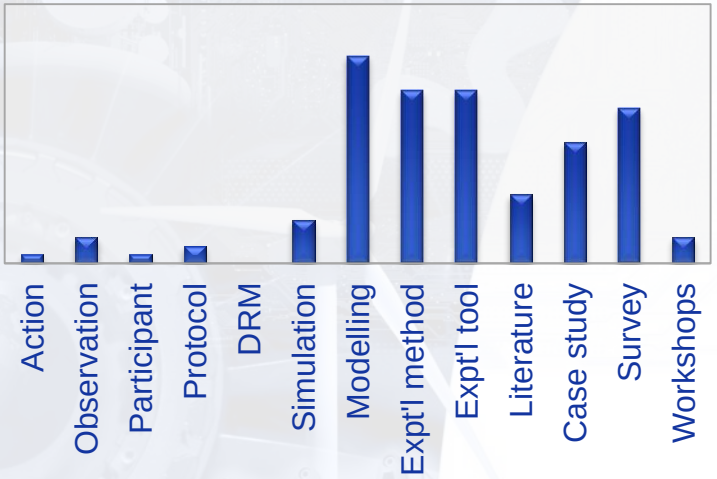


Research methods used in ICED09 Papers

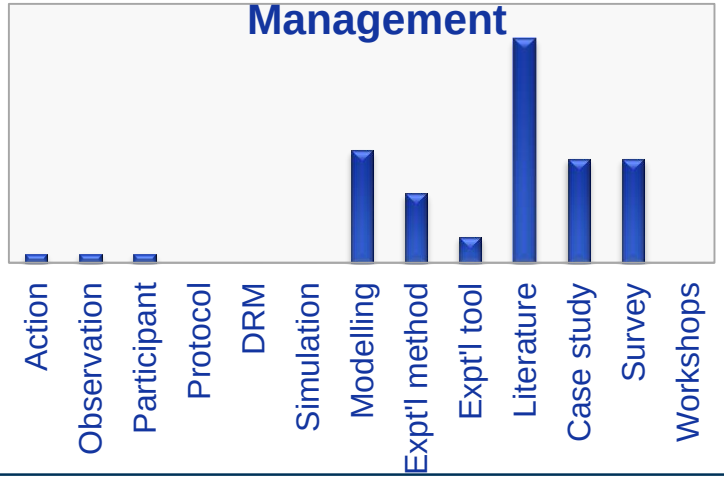
Human Behaviour



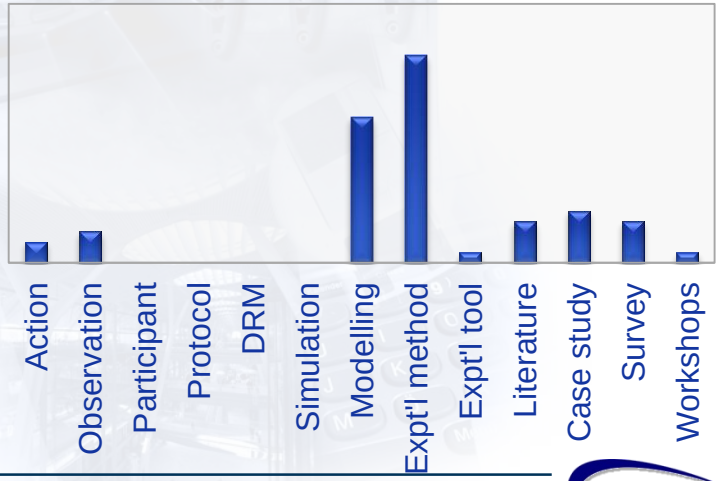
Design Processes



Design Organisation and Management



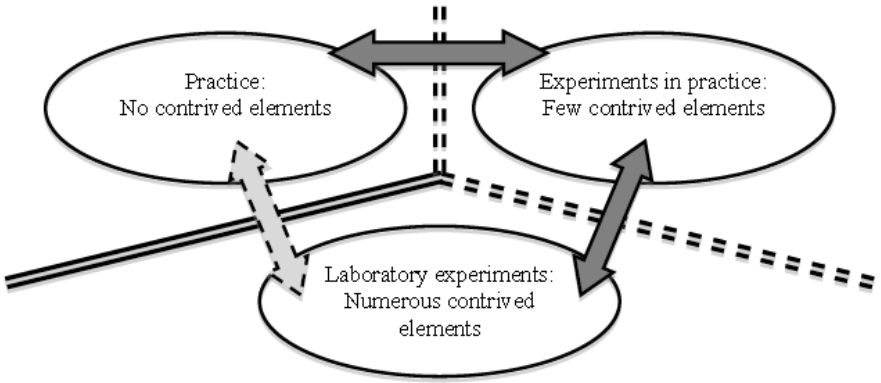
Design for X, Design to X

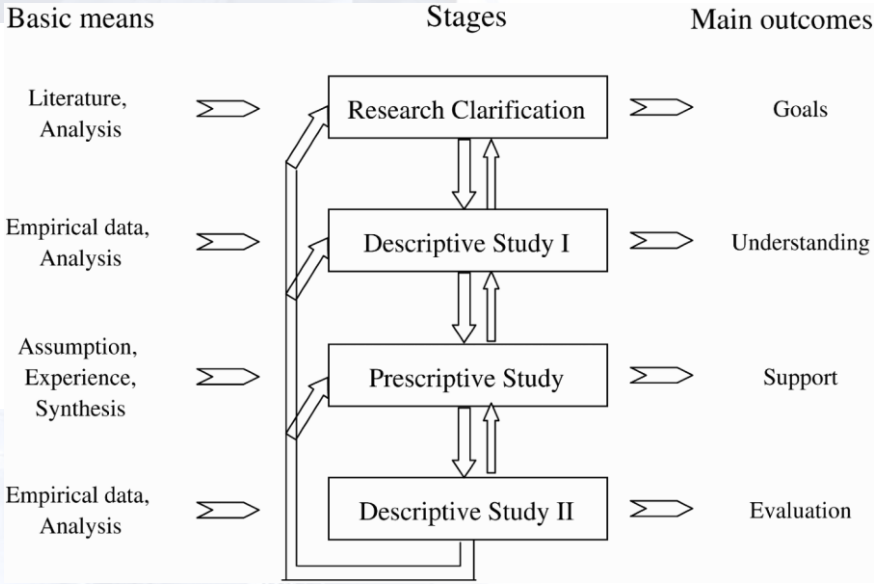


Developments in Research Methodology

Some attempt at consolidation of design research methodologies

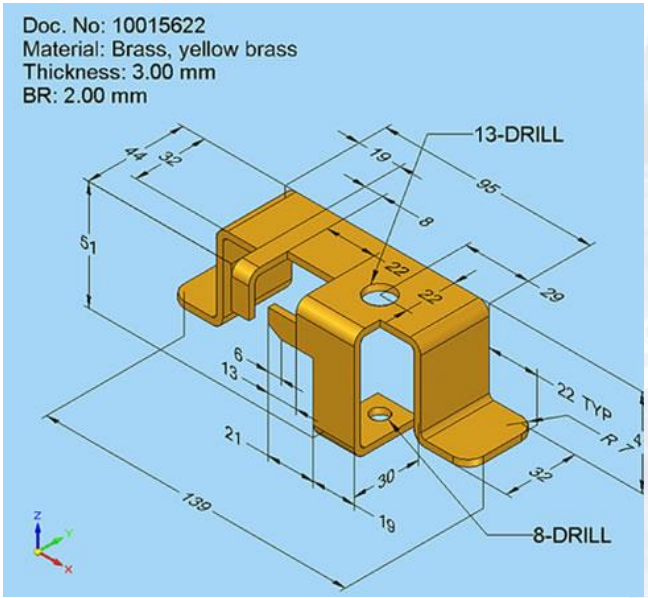
- Driven especially by Blessing and Chakrabarti's Design Research Methodology
- But also with strong developments in design observation, especially through a summer school from the iDON network

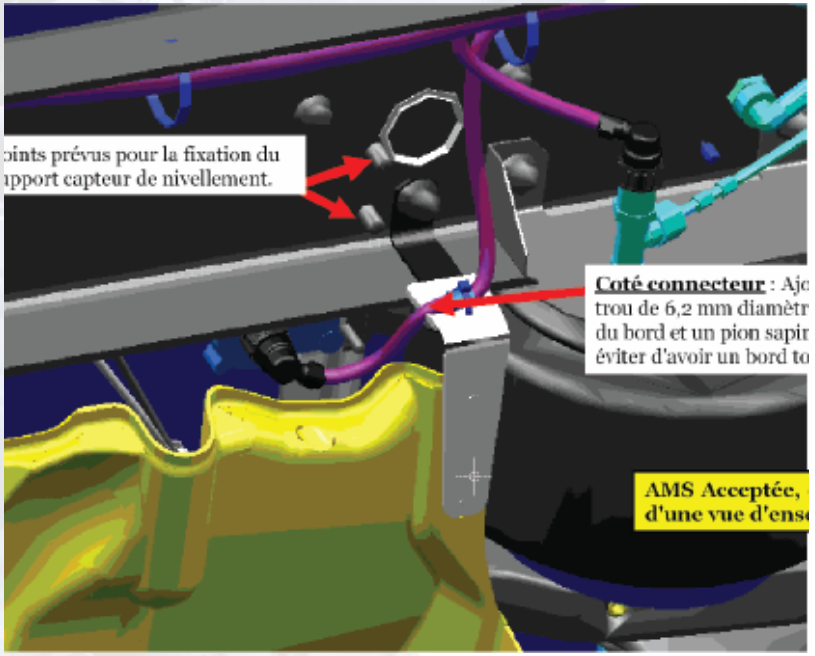


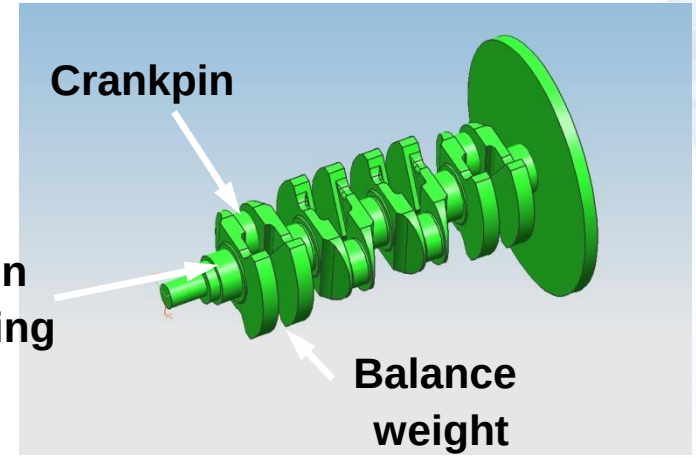


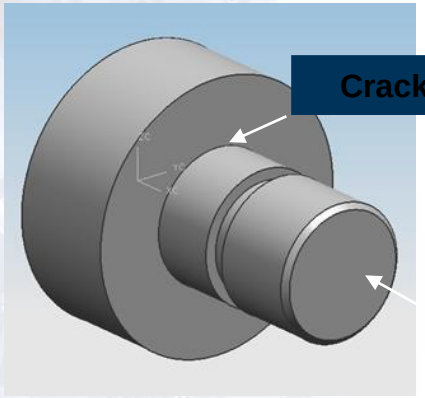
METHOD AND TOOL DEVELOPMENT

Use of annotation









Standardised anchoring mechanisms

Interface Module

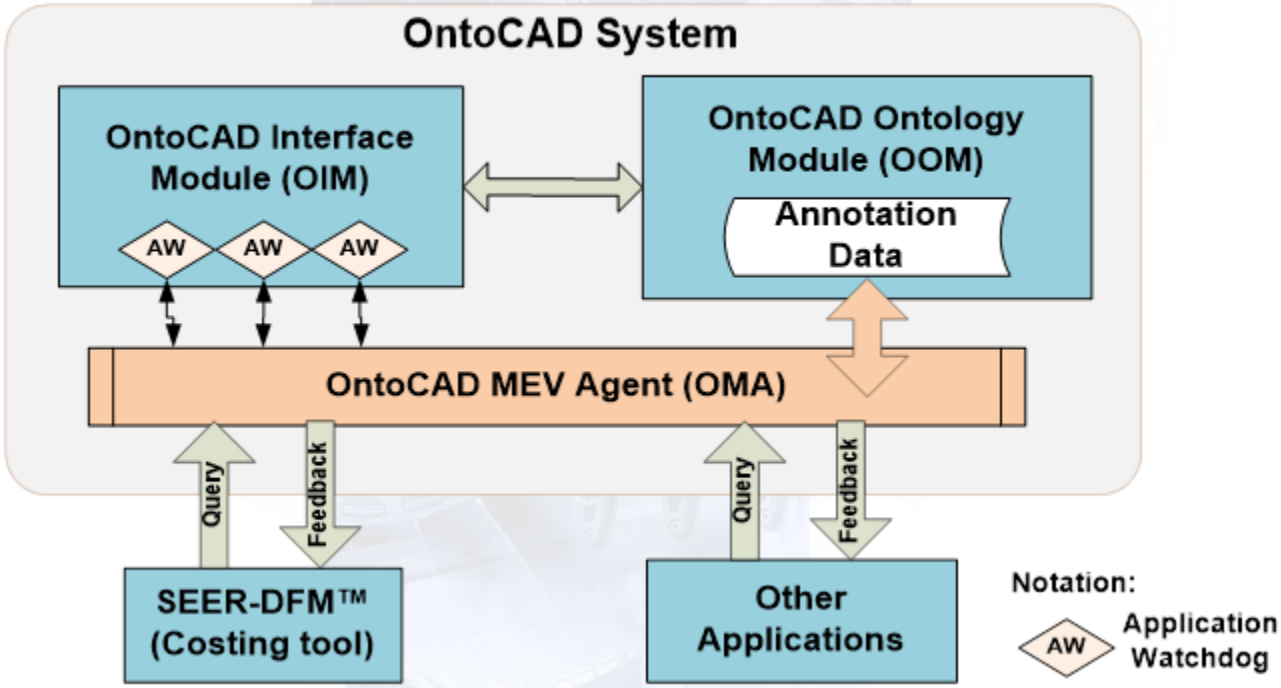
- Based on CAD
- Various granularities

Ontology Module

- Multiple engineering viewpoints
- Hierarchical ontology models

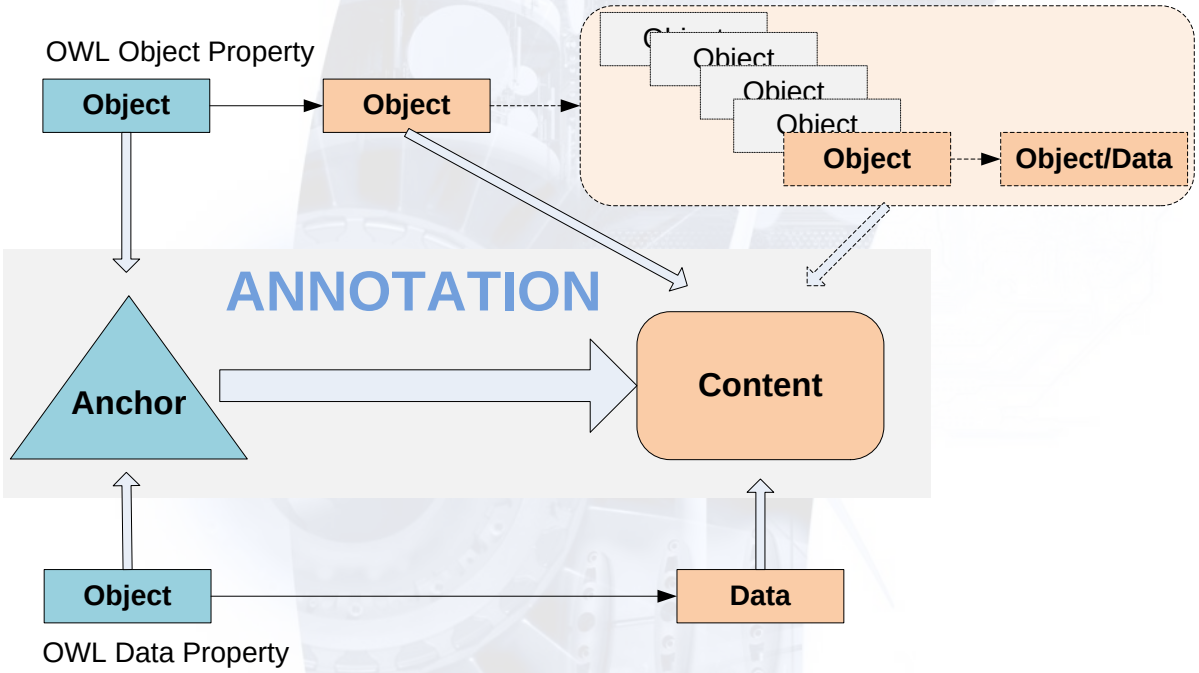
MEV Agent

- Management
- Communication

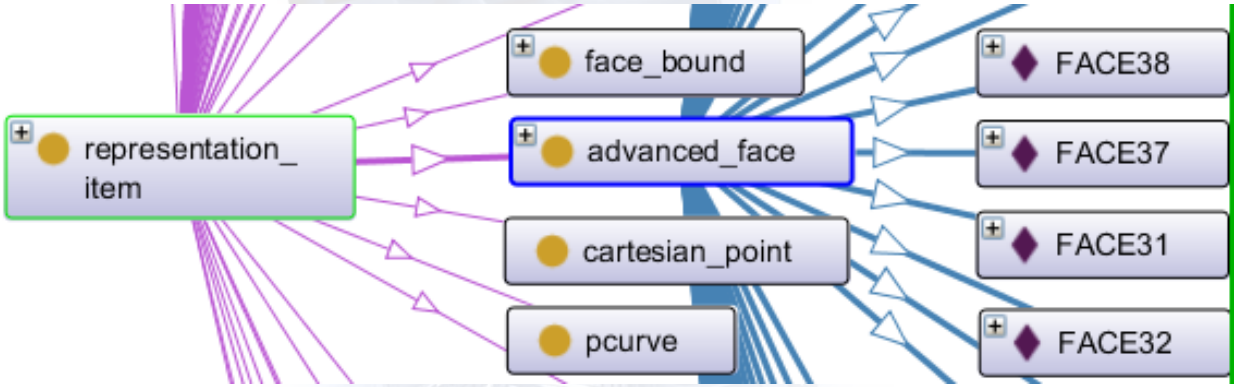


OntoCAD: Ontology Driven Semantic Annotation to CAD Systems

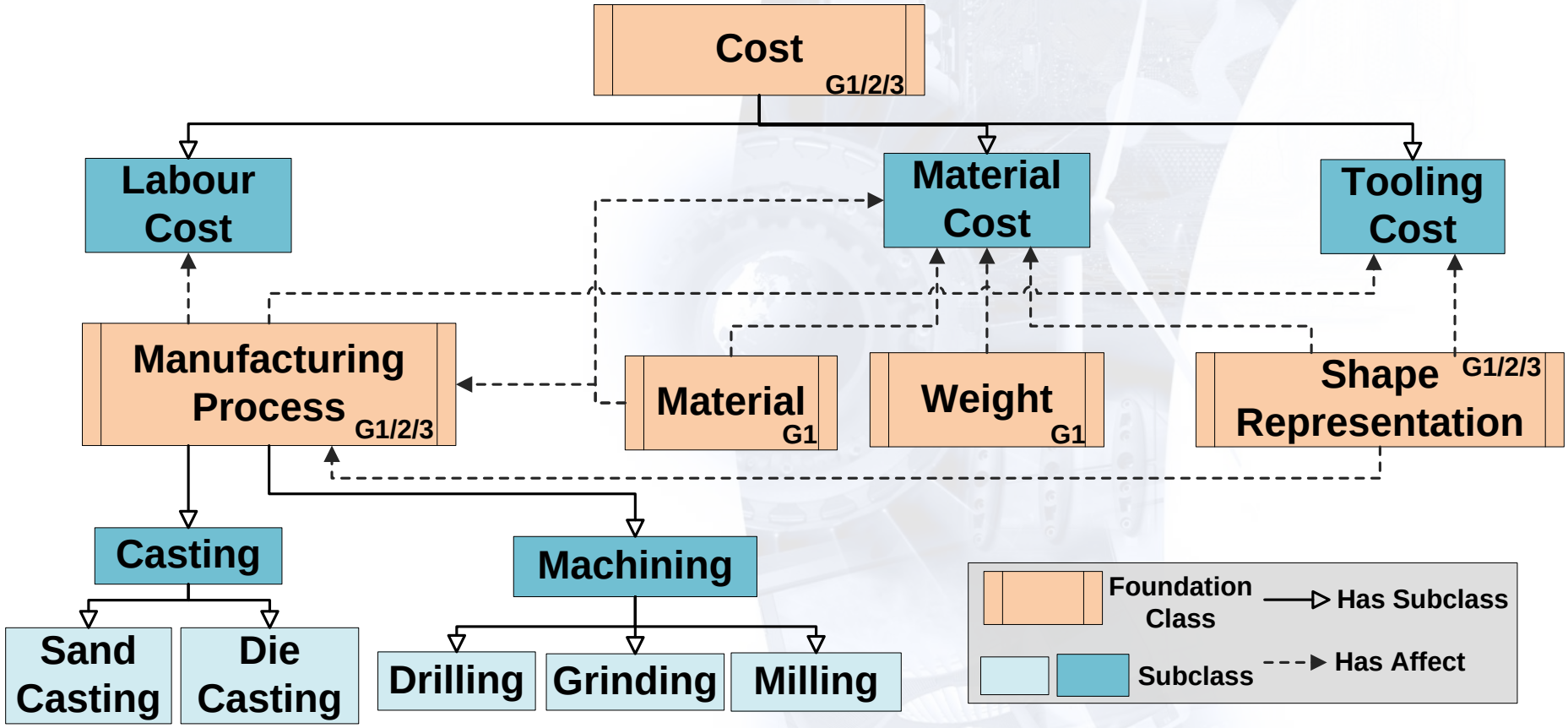
Annotation structures



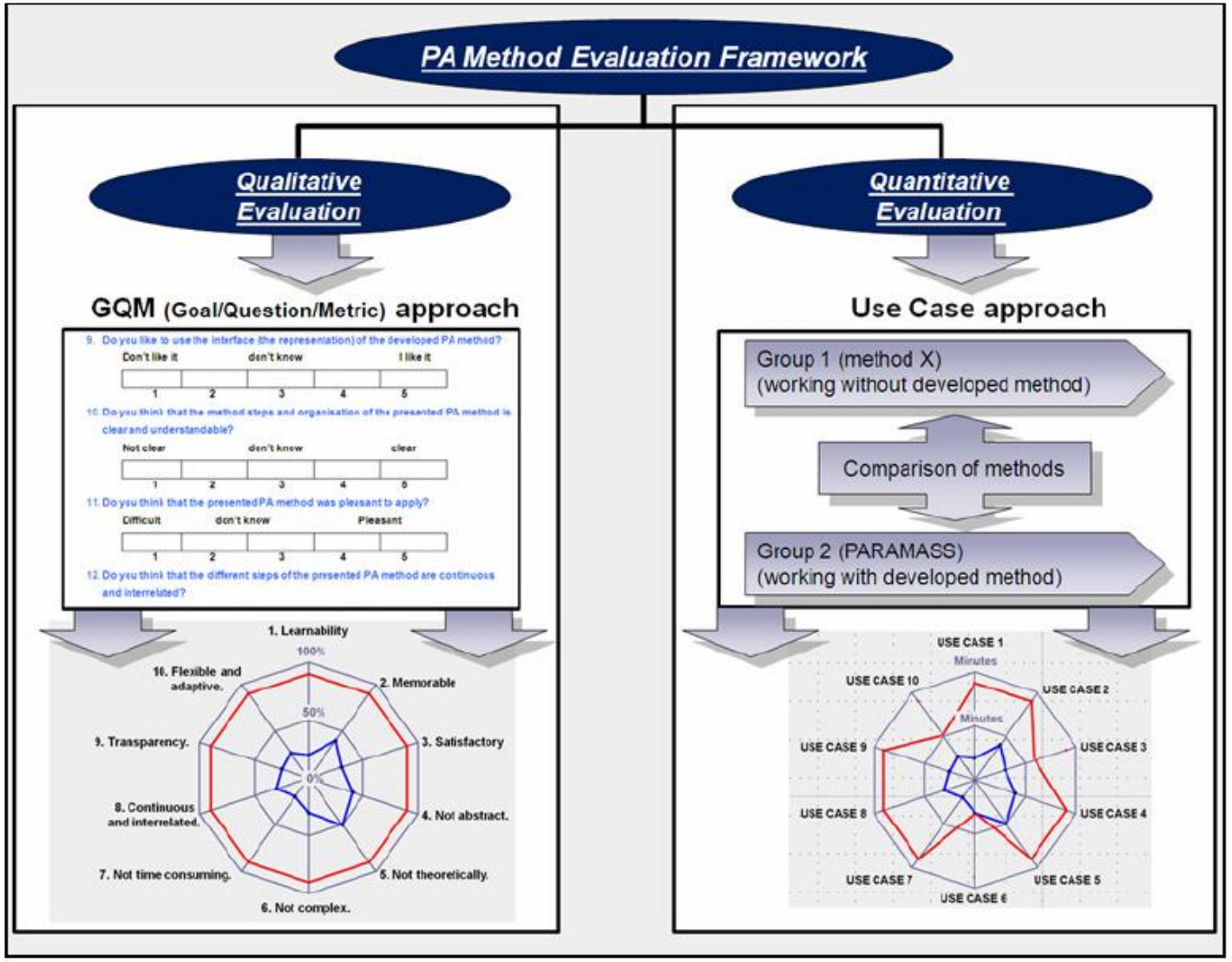
Anchoring mechanism



Experimental application



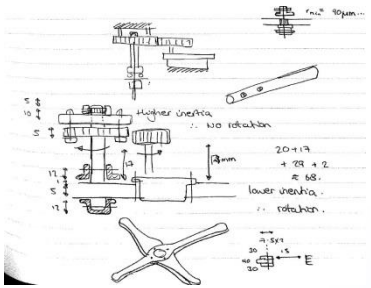
Evaluation of results

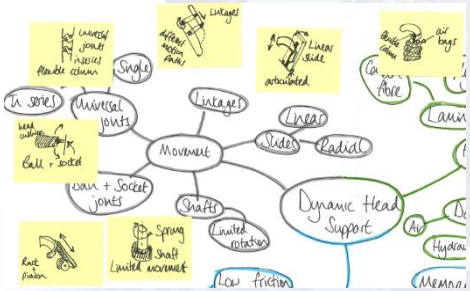


STUDY OF INDIVIDUAL DESIGNERS

Primary Studies

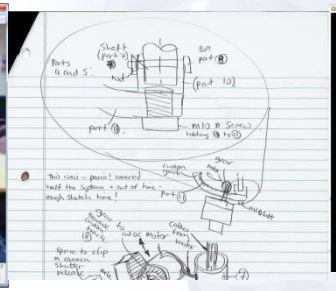
Study 1





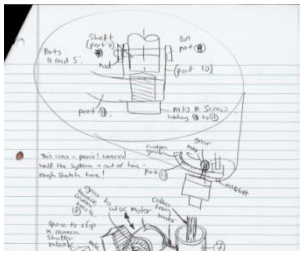
Study of logbooks of engineers
Coded directly through detailed schema
7 participants, 22 weeks
1000+ individual tasks identified
Results correlated with creativity tests

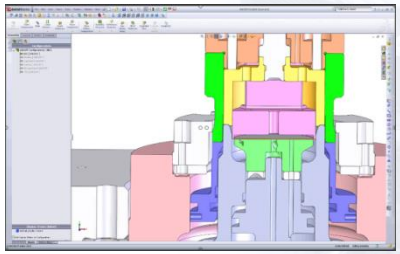
Study 2



Study of working in lab experiment; recorded through video, screen capture, logbook capture
All data sources synchronised, and then coded through detailed schema
12 students, 8 industry engineers - 4.5 hour set design task - 500+ tasks identified - correlated with creativity tests

Study 3





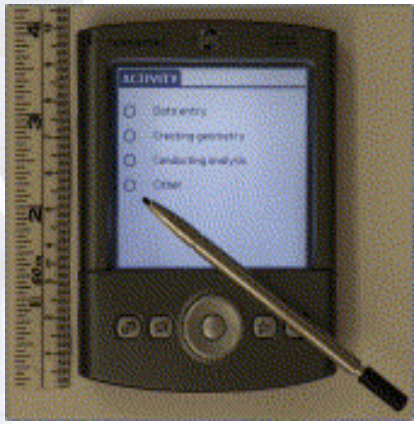
Industrial study through logbooks and screen capture
Based in collaborating company
100 + hours data analysed
4 experienced participants

Source: Chris Snider

Work Sampling- Mark Robinson, Leeds

Work sampling: taking numerous ‘snap-shots’ of a job to build a detailed overall picture:

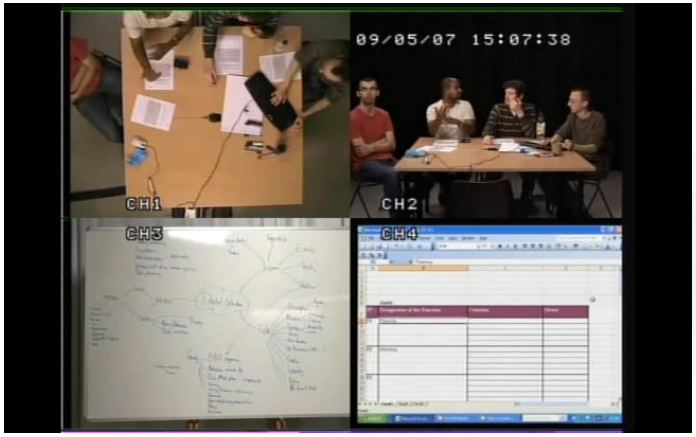
- Engineers each carry a PDA for 20 working days.
- At random alarm-points within each hour, they categorise their current work activity by entering data on 12-16 screens.
- With sufficient data, it is possible to precisely infer the percentage of time spent engaged in each activity.
- Multi-level task categories are used to examine work from multiple perspectives in a detailed manner.
- A methodological development incorporates additional questionnaires to collect job-level data in a longitudinal manner throughout the study.



STUDY OF DESIGN TEAMS

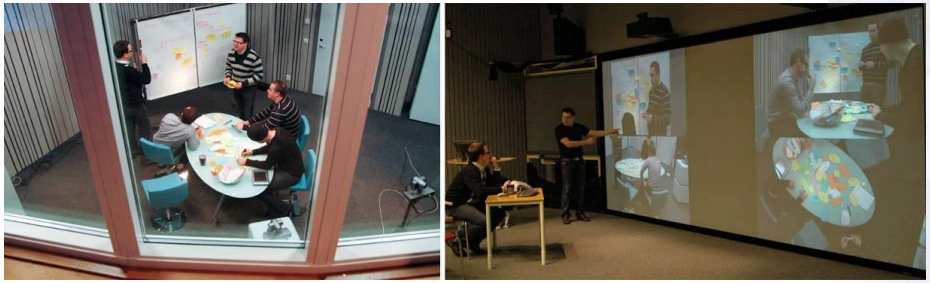
Design Observation Laboratories

Number of DO groups in Europe and US - iDONe setup following ICED 07 - Stanford, Bath, Lulea, Grenoble, Zagreb, Turin

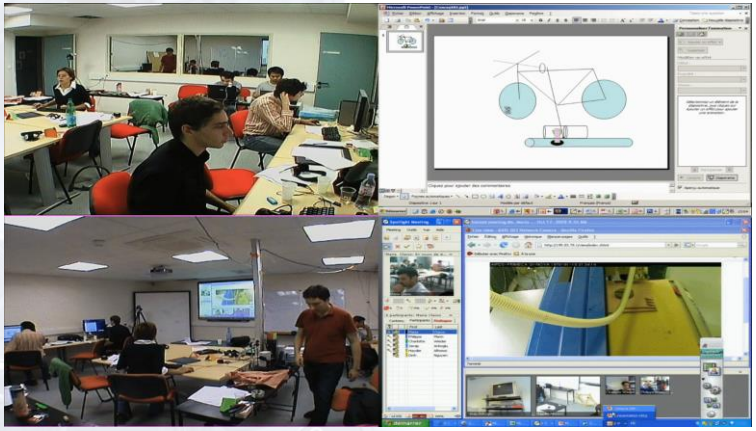


Bath

Stanford



Lulea



Grenoble

Empirical studies in industry

- **Interdisciplinary study:**
- Department Machine Elements and Product development, TU Darmstadt and Institute of Theoretical Psychology, University Bamberg
- **Aim:** Identification of the main factors and their inter-relations influencing collaborative design work

Methods	Fields of influencing factors			
	Process	Company	Individual	Group
Observation	●	●	●	●
Interviews	●	●	●	●
Diary-sheets	●	●	●	●
Questionnaires			●	●
Computer-simulated problems			●	●
Video-feedback	●	●	●	●

Source: Petra Badke-Schaub, TU Delft

What determines successful collaboration of teams?

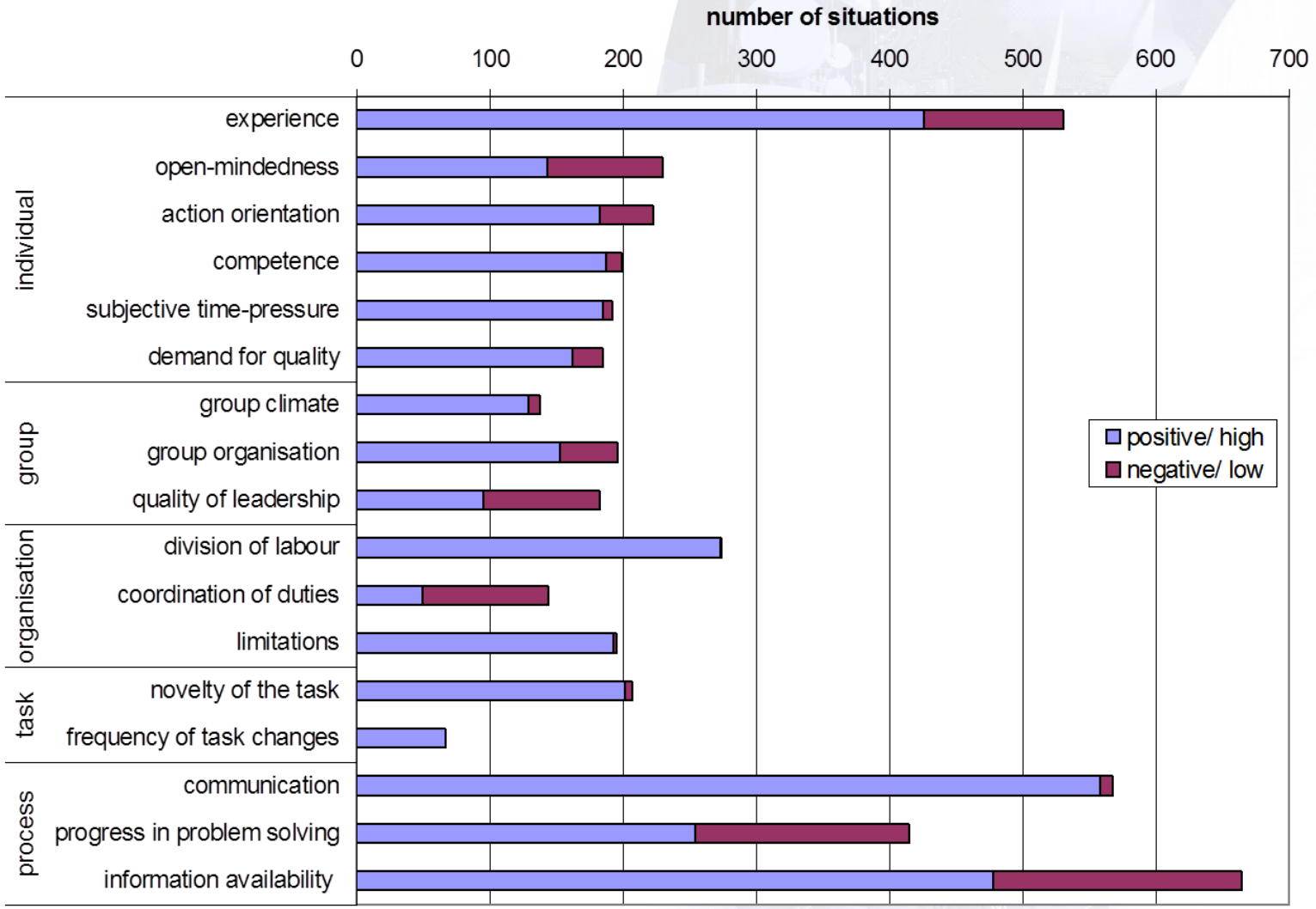
Critical situations as turning points in the design project

- Routine and critical situations
- Types of critical situations
- Mechanisms of successful and deficient processes are related to different types of critical situations
- Identified by coding - assigning passages - sentences - sequences to types of critical situations
- Assessment of experience of 15 designers by diary/interview to explore critical situation-related experience = experience in dealing with this particular issue

Types of Critical Situations

analysing the goal space: clarifying concept- or embodiment related requirements	goal analysis
setting goals by decisions	goal decision
generating proposals and solution ideas on the design concept or on the embodiment level	solution search
analysing and evaluating solution ideas	solution analysis
selection of solutions, solution principles	solution decision
reaction to external disturbances and interruptions which do not concern the own project	disturbance management
answer to conflicts or behaviour that causes conflicts related to the own project	conflict management

Relevance of experience



Concluding remarks

- There are many academic and industrial perspectives on design
- These perspectives lead to an enormous diversity of subjects of research and of the methodologies adopted.