IT-Systems and Human Factors

Are modern information systems safe and efficient?

Anders Jansson

Cognitive work analysis

- Efficiency relative a purpose or goal
  - Safety
  - Productivity
  - Effectiveness
  - Health
  - Trust / Confidence

- Efficiency relative a mean or measure
  - Speed
  - Learnability
  - Effectiveness
  - Few problems
  - Satisfaction

Technological motives

- Safer systems!
  - Automation can protect against the "human factor"!

- More efficient!
  - Tax money must be used efficiently!

- Increase productivity!
  - Technology is important on a competitive market

- Healthier!
  - Modern technology can improve working conditions
Benefits of automation

- Reduces workload and fatigue
- Precision in the handling of routine tasks
- Reliability
- Increased efficiency, productivity and safety
- Economical utilization of machine
- Avoid effects of human error types
- Avoid effects of human error forms

Interaction Design

Goal 1: Safety
Goal 2: Efficiency
Goal 3: Productivity

Method for reaching the goals:
Good cognitive working conditions

Goal 4: Health
Goal 5: Confidence

Systems with interfaces with high usability

Technological development

- Different phases in the history of technology
  - Mechanization
    - Taylorism – dividing work into parts
  - Automation and centralization
    - Task analyses connected to working tasks
  - Computerization
    - From physical direct interactions to conceptual (cognitive) interactions
**Safe systems?**

- 40% of all systems will never be used!
- 40% result in marginal gains
- Only 10-20% will reach the goals they were intended for
- The problems are almost never technical!
  - Organizations, users and clients are the common explanations for the failures

**Efficient systems?**

- Mechanization, centralization and automation resulted in higher productivity
- Computerization has not shown the same positive trend
- After 1973:
  - Growth/working hour is decreasing in USA, growth/working year is decreasing worldwide
  - More white-collar workers – but the same productivity

**Productive systems?**

- 40% of all systems will never be used!
- 40% result in marginal gains
- Only 10-20% will reach the goals they were intended for
- The problems are almost never technical!
  - Organizations, users and clients are the common explanations for the failures
Better health?

- Working tasks with high demands, low levels of control, and bad support in the form of imperfect working tools make people sick.
- An increasing amount of reports show that modern working conditions are problematic.

How do you feel at work?

- The Karasek-Theorell Model:

  - Low control and low support lead to low job satisfaction.
  - High control and high support lead to high job satisfaction.
  - Low control and high support lead to stress.
  - High control and low support lead to burnout.
### Technology and Work

- **A technological perspective:**
  - Innovations result in new tools to solve old problems
  - We know quite well how technology works and how it can be improved

- **A work-related perspective:**
  - Identification of problems and needs lead us to new tools
  - We know surprisingly little about humans and their needs

### Technological development

- Vicente wants us to start, not with the technology, and not with the old ways of doing things, but by analyzing the constraints on how the work can be done

- Work with a high degree of interaction with technology is qualified work

- Operators (users) are experts with a unique domain knowledge – that competence is important to consider when designing new tools

### Conclusions chapter 1

- A work-related perspective!

- Socio-technical analyses are important tools when analysing work

- The technological development must make it possible for operators and users to utilize their knowledge to control actions and situations which have not been possible to foresee by the system engineers
Conclusions chapter 1 cont.

- All functionality that is needed to complete qualified work must be identified in such analyses.
- General knowledge about human cognitive capabilities and limitations must be put into practice when designing work tools.
- A high degree of autonomy and possibilities to affect that work is important!

CWA-framework

<table>
<thead>
<tr>
<th>Behavior-shaping constraints</th>
<th>CWA-phases</th>
<th>Chapter in the book</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Work Domain</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>B. Control tasks</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>C. Strategies</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>D. Social organization</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>E. Domain specific knowledge</td>
<td>5</td>
<td>11</td>
</tr>
</tbody>
</table>

Motives for analyses

- Decision support systems must support the work tasks!
- Examples of bad design are so common that we have become used to them.
- The explanation is very often limited knowledge about working conditions and criteria for good design!
Socio-technical analyses

- The work-related perspective leads us to socio-technical work analyses
- Two different perspectives:
  - The traditional, cognitive perspective
  - The new, ecological perspective

Two different paradigms

- Ecological perspective
  - The purpose is to find the environmental conditions that act as constraints on the working task
  - The ecological constraints/conditions are the point of departure for the design process
- Cognitive perspective
  - The purpose is to find the cognitive characteristics that act as the limitations and constraints on the working task
  - Cognitive characteristics are the point of departure for the design process
Cognitive perspective 1

- Analyses of cognitive demands
  - For example effects on working memory
- The analyses evaluate the ergonomics of the user interface

Cognitive perspective 2

- Analyses in terms of mental models
- Different types of mental models
  - Structural models
    - Descriptive knowledge, often whole-parts
  - Functional models
    - Procedural knowledge, often details

Cognitive perspective 3

- Functional mental models
  - Advantages
    - A detailed picture of what is important to consider in the design process
    - Often necessary in order to understand important and difficult moments in work
  - Disadvantages
    - Design risks: The operators may have maladaptive models and may therefore also misinterpret relations in the system
Information analyses

- Vicente about work analyses
  - Analyses of working tasks must always contain analyses of BOTH the cognitive prerequisites AND the contextual contraints
  - Analyses of contextual constraints and demands MUST be the FIRST step

Analyses of contexts

- Consequences of modern technology
  - From mechanization, via centralization and automation, to computerization
  - Technology has changed the operators relations to their working tasks
    - Indirect relations to the process
    - Indirect relations demands inferences
  - Inferences and deductions have been investigated in research on decision-making

Operator tasks 1
Operator tasks 5

Decision making

- Classical decision making
  - Probability models are the point of departure
  - Gives a picture of the human as a bad “intuitive statistician”

- Naturalistic and dynamic decision making
  - Integrates perception och cognition
  - Gives a picture of the human as a good “intuitive engineer”
Cognitive continuum

Intuition → Natural task continuum → Analysis
Intuition → Artificial task continuum → Analysis
Intuition → Cognitive task continuum → Analysis

Long haul driving

- Current Situations
- Future Situations
The role of the driver?

Operational

- Spatial perception
- Visual scanning
- Attention
- Concentration
- Orientation
- Reaction time
- Cognitive processing
- Visual-motor integration

Tactical

- Driving skills
- Driving behaviour
- Adapting speed
- Driving decisions

Strategic

- Perceptive decisions
- Planning abilities
- Autonomous Control
- Strategic Control
- Monitoring Supervision

Engineering traditions

Classical approach
- Well-designed and scrupulously maintained systems
- Complete and correct procedures
- People behave as expected, and as they are trained to
- Designers can foresee all contingencies and provide appropriate responses

Resilience engineering
- Humans can learn to overcome design flaws and functional glitches
- Humans can adjust their performance in order to meet actual demands
- Humans can interpret procedures and apply them to meet actual conditions
- Humans can detect and correct when things fail
From conditions to effects, *in theory*

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Psychological Domain</td>
<td>Activity Domain</td>
</tr>
<tr>
<td>Calculable</td>
<td>Physical Domain</td>
</tr>
<tr>
<td></td>
<td>Results Domain</td>
</tr>
</tbody>
</table>

Situated usefulness

<table>
<thead>
<tr>
<th>Character of Usefulness</th>
<th>Character of Utility</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Character of Utility</td>
</tr>
<tr>
<td></td>
<td>Achieve desired effects</td>
</tr>
<tr>
<td></td>
<td>Avoid undesired effects</td>
</tr>
</tbody>
</table>

- Potentiality
- Resilience
- Effectiveness
- Safety

The lost perspective

- Gotthierna - 1991
- AF447 - 2009
- Forsmark - 2006
- Fukushima - 2011
The Lost Perspective
philosophically speaking

- While trying to refute the Cartesian gap by use of impeccable mathematics, knowledge becomes reduced to describable facts and/or interpretations of the past and is validated in the future, either as verified predictions or an understanding judged as relevant.
- What is lost is the present → reduced to a state occupying an infinitesimal short period of time.

However, actions take place in the present, decisions are made in the present, awareness is a phenomenon of the present, human beings exist in the present.