
| Time (start) | Time (end) | DS | SF | SV | GI | C | PC | P | Text |
|---|---|---|---|---|---|---|---|---|---|
| … | … | … | … | … | … | … | … | … | … |
| 11:45:21 | 11:45:49 | 1d | ps | | | vf | t | B | test with the complete fruit press … |
| 11:45:49 | 11:46:00 | 1d | ps | | | vf | t | B | convert … |
| 11:46:00 | 11:46:19 | 1d | ps | | | vf | t | A | let's try both |
| 11:46:19 | 11:46:32 | 2i | s | s1 | | vn | m | B | we've got the fruit press, put the juice trains in |
| 11:46:32 | 11:46:51 | 2i | ps | | | vf | m | E | does it make sense to rebuild the control unit? |
| 11:46:51 | 11:47:00 | 2i | bm | | | vn | m | E | convertible, the symmetric membrane fixing? |
| 11:47:00 | 11:47:28 | 2i | bm | | | vf | t | A | we will talk about that later … |
| 11:47:28 | 11:47:53 | 2i | ps | | | vf | t | E | test control unit middle of nov., with interior dec. |
| 11:47:53 | 11:48:00 | 2i | s | s1 | | vf | t | A | juice drains are there from last year |
| 11:48:00 | 11:48:40 | 1d | | | m | vf | t | E | now we are jumping a little bit |
| … | … | … | … | … | … | … | … | … | … |



**Figure 5.4** Compiling the design process using direct and indirect investigation methods.

Additionally, the documents produced by the designers (drawings) were also collected, and they were asked about their processes and their results. These interviews, based on the diary sheets and the documents, provided important information about the design process and helped us to understand the development of the solutions and the technical decisions. Figure 5.4 depicts the procedure of compiling data on the design process and presents an excerpt of a revised on-line-protocol.

## Individual prerequisites

Individual behaviour (e.g., communication generated by a person) is influenced by several factors. A reduction of the complex cognitive, emotional, and behavioural processes to one or two "important" characteristics seems almost impossible. People usually behave according to the situation at hand: few paradigms can be considered universally valid for all situations or all individuals' behaviours. For example, a person confronted with a novel, complex problem will take longer to analyze it if there is enough time, if the problem is important or if there seems to be a good chance of solving the problem, than he or she would in a situation in which there is no time or the problem is less important. Therefore, different methods were chosen in order to assess the individual prerequisites (see Table 5.1).

Biographical data and personal opinions about the working environment were mainly collected by means of semi-structured interviews. Assuming that

design processes are fairly typical examples of complex, realistic problem-solving processes, it is important to look at the engineers' strategies in complex and novel situations. The designers' ability to deal with complex problems was assessed by analyzing the thinking and action-regulation behaviour of each designer while solving computer-simulated problems (cf. Dörner and Wearing 1995). Each designer was asked to solve two problems that were novel, complex and dynamic. These simulations were selected because they required different manners and strategies of action regulation. Contrary to design tasks, computer-simulated problems can be solved without any specific textual experience. The behaviour of the subject is not measured as a single numerical variable (e.g., the "quality" of problem solving); instead, the focus is on the action-regulation styles of the individual (i.e., the planning process of the subject), consisting of sequences of different variables such as the evaluation of questions, decisions, etc. In using these standardized computer-simulated problems, individual heuristics and strategies can be investigated (Badke-Schaub and Tisdale 1995). Other studies have shown that the strategic behaviour of designers in these simulated problems is similar to behaviour in design work. These similarities can be interpreted as individual action styles (Eisentraut 1997).

The assessment of the heuristic and social competence of the designers was based on their design process (captured in the final protocols and the diary sheets) and on a self-assessment questionnaire developed by Stäudel (1987). Several studies on heuristic competence indicate that a positive self-assessment of problem-solving abilities supports successful problem solving in complex situations (cf. Stäudel 1987). The social competence of the designers was assessed using the observations of group activities, both during the design work and during the work with the computer-simulated problems.

**Table 5.1.** Variables and methods for compiling individual prerequisites

| Field of data | Variables | Methods |
|---|---|---|
| Biographical data | Age<br>Professional education, career<br>Qualifications and experience | Semi-structured interview<br>Questionnaire |
| Work environment | Motivation; job satisfaction<br>Evaluation of the organization<br>Evaluation of the actual project<br>Relationship to colleagues and to superiors | Semi-structured interview<br>Questionnaire |
| Ability to deal with complex problems | Analysis and information-gathering<br>Action planning<br>Dealing with time pressure<br>Dealing with stress | Computer-simulated micro-worlds<br>Fire (individual)<br>Machine (individual)<br>Manutex (group) |
| Competence | Heuristic competence<br>Social competence | Questionnaire (Stäudel, 1987)<br>Observing and analyzing the interactions of the group |
| Abilities concerning the design process | Clarification of the task<br>Search for conceptual solutions<br>Selection and control | Diary sheets/marks-on-paper<br>On-line protocol of the design process<br>(Video and tapes) |