Improving design processes through structured reflection: feedback

Citation for published version (APA):

Document status and date:
Published: 01/01/2001

Document Version:
Publisher’s PDF, also known as Version of Record (includes final page, issue and volume numbers)

Please check the document version of this publication:
• A submitted manuscript is the author's version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
• The final author version and the galley proof are versions of the publication after peer review.
• The final published version features the final layout of the paper including the volume, issue and page numbers.

Link to publication

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

• Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
• You may not further distribute the material or use it for any profit-making activity or commercial gain
• You may freely distribute the URL identifying the publication in the public portal.

If the publication is distributed under the terms of Article 25fa of the Dutch Copyright Act, indicated by the “Taverne” license above, please follow below link for the End User Agreement:
https://www.tue.nl/index.php?id=71870

Take down policy
If you believe that this document breaches copyright please contact us at:
openaccess@tue.nl
providing details and we will investigate your claim.
Improving Design Processes through Structured Reflection: Feedback

Isabelle M.M.J. Reymen

SAI Report 2001/4
October 2001
Eindhoven, The Netherlands
Improving Design Processes through Structured Reflection: Feedback

Isabelle M.M.J. Reymen

Abstract

The approach to and results of the empirical study Isabelle Reymen performed at the end of her Ph.D. research project is described. The Ph.D. project resulted in a design philosophy, a design frame, a design method, and a prototype software tool. The empirical study has been performed to get feedback on these results from the design practice. In the empirical study, expert designers gave feedback on all results in an interview, whereas junior designers used the design method and the prototype during one day and evaluated both at the end of the day. The feedback is only a first confrontation with design practice to judge the generality (domain independence), the relevance, and the potential usefulness of the results for design practice.

The goal of this report is to offer researchers more information about the performed empirical study and its results. The report includes two main parts: The first part concerns the approach to the feedback, including a detailed description of the protocol to get feedback from the junior and experts designers. The second part concerns the analysis and synthesis of the raw data received as feedback and the final results of the feedback. More about the Ph.D. project and its results can be found in the Ph.D. thesis, which is also published as SAI Report 2001/1.

Keywords

Design research ; empirical study / design theory; domain independence / design method ; reflection / design process ; description / multidisciplinary engineering design
## Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABSTRACT</td>
<td>3</td>
</tr>
<tr>
<td>CONTENTS</td>
<td>5</td>
</tr>
<tr>
<td>1 INTRODUCTION</td>
<td>7</td>
</tr>
<tr>
<td>2 APPROACH TO THE FEEDBACK</td>
<td>9</td>
</tr>
<tr>
<td>2.1 Expert designers</td>
<td>9</td>
</tr>
<tr>
<td>2.2 Junior designers</td>
<td>9</td>
</tr>
<tr>
<td>2.3 Analysis and synthesis of the feedback</td>
<td>9</td>
</tr>
<tr>
<td>2.4 Selection of the designers</td>
<td>10</td>
</tr>
<tr>
<td>3 DETAILED PROTOCOL FOR THE EXPERT DESIGNERS</td>
<td>11</td>
</tr>
<tr>
<td>3.1 Preparation of the confrontation</td>
<td>11</td>
</tr>
<tr>
<td>3.2 Confrontation</td>
<td>13</td>
</tr>
<tr>
<td>3.3 Processing of the data</td>
<td>19</td>
</tr>
<tr>
<td>4 DETAILED PROTOCOL FOR THE JUNIOR DESIGNERS</td>
<td>21</td>
</tr>
<tr>
<td>4.1 Preparation of the confrontation</td>
<td>21</td>
</tr>
<tr>
<td>4.2 Confrontation</td>
<td>23</td>
</tr>
<tr>
<td>4.3 Processing of the data</td>
<td>26</td>
</tr>
<tr>
<td>5 ANALYSIS AND SYNTHESIS OF THE FEEDBACK</td>
<td>29</td>
</tr>
<tr>
<td>5.1 Expert designers</td>
<td>29</td>
</tr>
<tr>
<td>5.1.1 Feedback of the expert designers on the design philosophy</td>
<td>29</td>
</tr>
<tr>
<td>5.1.1 Feedback of the expert designers on the design frame</td>
<td>29</td>
</tr>
<tr>
<td>5.1.2 Feedback of the expert designers on the design method</td>
<td>30</td>
</tr>
<tr>
<td>5.1.3 Feedback of the expert designers on the prototype software tool</td>
<td>33</td>
</tr>
<tr>
<td>5.2 Junior designers</td>
<td>35</td>
</tr>
<tr>
<td>5.2.1 Evaluation of the design method by the junior designers</td>
<td>35</td>
</tr>
<tr>
<td>5.2.2 Evaluation of the prototype software tool by the junior designers</td>
<td>37</td>
</tr>
<tr>
<td>6 RESULTS OF THE ANALYSIS AND SYNTHESIS</td>
<td>43</td>
</tr>
<tr>
<td>6.1 Feedback on the design philosophy</td>
<td>43</td>
</tr>
<tr>
<td>6.2 Feedback on the design frame</td>
<td>43</td>
</tr>
<tr>
<td>6.3 Feedback on the design method: expert designers</td>
<td>43</td>
</tr>
<tr>
<td>6.4 Feedback on the design method: junior designers</td>
<td>45</td>
</tr>
<tr>
<td>6.5 Feedback on the prototype software tool: expert designers</td>
<td>46</td>
</tr>
<tr>
<td>6.6 Feedback on the prototype software tool: junior designers</td>
<td>47</td>
</tr>
<tr>
<td>7 CONCLUSIONS</td>
<td>49</td>
</tr>
</tbody>
</table>
REFERENCES

SAI REPORTS
1 Introduction

This report describes the approach to and results of the empirical study I performed to get input from the design practice at the end of my Ph.D. research project. The results of the Ph.D. project are a design philosophy, a design frame, a design method, and a prototype software tool. In the empirical study, expert designers gave feedback on all results in an interview, whereas junior designers used the design method and the prototype during one day and evaluated both at the end of the day. The feedback is only a first confrontation with design practice to judge the generality (domain independence), the relevance, and the potential usefulness of the results for design practice. More about the Ph.D. project and its results can be found in [Reymen, 2001a] or [Reymen, 2001b].

The goal of this report is to offer researchers more information about the performed empirical study and its results. In the report, two main parts can be recognised: Chapters 2, 3, and 4 deal with the approach to the feedback whereas Chapters 5 and 6 deal with the analysis, synthesis, and results of the received feedback. The report starts in Chapter 2 with a description of the approach to the feedback. In Chapters 3 and 4, the protocol to perform the feedback of the junior and experts designers, including documents about the preparation of the confrontation, the documents used to get the feedback, and the transcription schemes used, is discussed in more detail. Chapter 5 discusses the analysis and synthesis of the raw data received as feedback. The final results of the feedback are discussed in Chapter 6. The report ends in Chapter 7 with conclusions. The report is written in English, but some documents used for the preparation of the confrontation were written in Dutch and are included as such.
2 Approach to the feedback

The goal of this chapter is to offer the reader insight into the approach to the feedback. First, in Section 2.1, the approach to get feedback from the expert designers is described. Then, in Section 2.2, the approach to get feedback from the junior designers is summarised. Section 2.3 discusses the approach to the analysis and synthesis of the feedback. Finally, in Section 2.4, the selection of the expert and junior designers is motivated. A detailed description of the protocol of the expert and junior designers can be found in Chapters 3 and 4.

2.1 Expert designers

Six expert designers gave feedback on the preliminary versions of the design philosophy, design frame, and design method and on the latest version of the prototype software tool. I sent the designers a short letter with an explanation of the goal of the feedback and a brief description of my Ph.D. project. In a discussion of one hour, I explained each result briefly, using some figures, and I received feedback on the results, which I wrote down. Despite of the fact that I had an idea of what comments to expect, I asked open questions.

2.2 Junior designers

Six junior designers were invited for a whole day to give feedback on the use of a preliminary version of the design method and on the prototype software tool. In a document sent to the designers in advance, I asked them to choose one of their design tasks to work on during that day (while using the design method and tool). I also sent them an abstract of the Ph.D. thesis, a planning of the ‘design day’, and a list of participants.

The day started with a general introduction in which I explained that the day included two main parts, one before lunch and one after lunch. The first part started with a presentation of the design method. Then, the designers were asked to write down their expectations about the design method. They started working on their design task during a first design session, using the design method. When the session was finished, the designers were asked to give feedback on the use of the method. A group discussion was held to discuss the feedback. After lunch, a presentation of the prototype software tool was given and the designers were again asked to write down their expectations about the developed result. The second session started and designers could use the prototype on laptops they received for that purpose. After this second session, the designers could again give feedback individually and in a group discussion. The day was concluded with a final group discussion about the results and possible improvements of the results.

2.3 Analysis and synthesis of the feedback

The feedback of the expert designers was first summarised and typed and then synthesised in several iterations, using a transcription scheme to structure the data. The feedback of the junior designers (individual and group feedback) was first summarised, integrated, and classified following a transcription scheme. Then, the individual feedback was added to the group discussion (structured according to the transcription scheme) and synthesised. Several iterations of the analysis and synthesis of the feedback are given in Chapter 5. Results of the synthesis are descriptions of the feedback on each of the results of the Ph.D. work (the feedback of the expert and junior designers has not been combined). The descriptions can be found in Chapter 6. Suggestions for improvement of the design philosophy, the design frame, and the design method were taken into account in the further development of these results. The development of the prototype had stopped before the feedback on
the prototype was given, but the feedback was taken into account for describing possible improvements and extensions of the prototype (see [Reymen et al., 2001]).

2.4 Selection of the designers

As for the case studies I performed at the beginning of my project (see [Reymen, 2001c]), a distinction was made between junior and expert designers. The expert designers were almost the same designers I interviewed for the first empirical study. Some of the junior designers were the same as well; others were chosen based on the same criteria as for the case studies (see [Reymen, 2001c]). In Table 2.1, the designers that gave feedback are listed. All designers had a background in one of the three design disciplines I studied in this research project, namely architecture, mechanical engineering, and computer science. The design assignments the junior designers worked on during the whole day were the following: a computer game, a toolbox for the design and implementation of computer assisted surgery tools, a new sealing concept for lithographic machines, new types of churches, software support for the conceptual design phase of design processes of architects, and the design of clothes.

<table>
<thead>
<tr>
<th>DISCIPLINE</th>
<th>EXPERIENCE</th>
<th>NAME</th>
<th>DESIGN FIELD</th>
</tr>
</thead>
<tbody>
<tr>
<td>computer science</td>
<td>expert</td>
<td>W. van der Sanden</td>
<td>Panfox</td>
</tr>
<tr>
<td>mechanical engineering</td>
<td>expert</td>
<td>M. Koster</td>
<td>Philips CFT</td>
</tr>
<tr>
<td>architecture</td>
<td>expert</td>
<td>Kruithof</td>
<td>Daf</td>
</tr>
<tr>
<td>computer science</td>
<td>junior: Ph.D. on design</td>
<td>Albert Hofkamp</td>
<td>XX Architecten</td>
</tr>
<tr>
<td>computer science</td>
<td>junior: Ph.D. on design</td>
<td>Wilbert Alberts</td>
<td>Mecanoo</td>
</tr>
<tr>
<td>mechanical engineering</td>
<td>junior: Ph.D. on design</td>
<td>Raymond Habets</td>
<td>TU/e, mechanical eng.</td>
</tr>
<tr>
<td>architecture</td>
<td>junior: Ph.D. on design</td>
<td>Marcel Renkens</td>
<td>Philips CFT</td>
</tr>
<tr>
<td>industrial design</td>
<td>expert</td>
<td>Sander de Jonge</td>
<td>TU/e, civil eng.,</td>
</tr>
<tr>
<td>industrial design</td>
<td>expert</td>
<td>Nico Segers</td>
<td>KUB, theology</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bart van den Hoge</td>
<td>TU/e, architecture</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tineke Reijbroek</td>
<td>Paper Design bv</td>
</tr>
</tbody>
</table>

Table 2.1: The designers that gave feedback.

1 The last two designers are left out of the analysis because they belonged to a different design discipline.
3 Detailed protocol for the expert designers

The goal of this chapter is to offer detailed information about the protocol of the expert designers. Section 3.1 discusses the preparation of the confrontation of the results of the Ph.D. project with the expert designers. In Section 3.2, the documents used for the confrontation are discussed. Section 3.3 discusses the processing of the data.

3.1 Preparation of the confrontation

To prepare the confrontation of my results with the expert designers, I sent them an introductory document, possibly also a summary of our last interview, performed at the beginning of the Ph.D. project to get input from the design practice (see [Reymen, 2001c]), and a short description of my Ph.D. project. In Table 3.1, the introductory document is given (in Dutch). Table 3.2 gives the project description.

<table>
<thead>
<tr>
<th>Isabelle Reymen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stan Ackermans Instituut</td>
</tr>
<tr>
<td>Technische Universiteit Eindhoven</td>
</tr>
<tr>
<td>telefoon: +31 (0)40 247 2749; fax: +31 (0)40 246 8508</td>
</tr>
<tr>
<td>e-mail: isabelle @ win.tue.nl</td>
</tr>
<tr>
<td>homepage: <a href="http://www.win.tue.nl/cs/tt/isabelle/">http://www.win.tue.nl/cs/tt/isabelle/</a></td>
</tr>
</tbody>
</table>

Eindhoven, 8 december 1999.

Geachte Heer Koster,

Meer dan een jaar geleden hadden wij een gesprek over ontwerpen in het kader van mijn onderzoek. Inmiddels zijn de ideeën die ik mede hierdoor kreeg uitgewerkt en ben ik bezig deze op te schrijven voor publicatie in een proefschrift. Omdat ik de ontwikkelde ideeën graag nog wil toetsen op relevantie en bruikbaarheid voor de ontwerppraktijk, wil ik, indien mogelijk, hiervoor weer een beroep op u doen.

Mijn onderzoek is een verkennende studie die vertrok van observaties in de praktijk en in de literatuur en resulteert in domein onafhankelijke ondersteuning voor ontwerpers in de praktijk. De studie omvat de volgende vier resultaten: een ontwerpfilosofie, een ontwerpraamwerk, een ontwerpmethode en een ontwerpgereedschap. In bijlage vindt u een samenvatting van het onderzoek.

Graag maak ik met u weer een afspraak om de resultaten te bespreken. De discussie neemt maximaal 1.5u van uw tijd. De afspraak kan gemaakt worden tussen nu en eind februari, op een plaats die u verkiest. Ik bel u enkele dagen na ontvangst van deze brief om eventueel een afspraak te maken.

In ieder geval nogmaals hartelijk dank voor u deelname aan het begin van het onderzoek en reeds bij voorbaat dank voor eventuele reacties op de resultaten. U ontvangt in ieder geval nog een exemplaar van het proefschrift als dit klaar is voor verdediging.

Met vriendelijke groeten,

Isabelle Reymen

Bijlage: Samenvatting van het onderzoek

Table 3.1: Introductory document sent to the designers.
Domain independent support for reflecting on design situations

ABSTRACT
Isabelle Reymen

Research goal
In the world of designing, three fields of attention can be recognised; namely design practice, design education, and design research. The ambition of this research project is to decrease the gap between these fields by generating design knowledge that is based on literature and practice and that is made applicable for design practice and education.

In practice, designing is executed in many disciplines and in multidisciplinary design teams. Much literature about designing, however, concentrates on only one design discipline. The goal of this research is to develop domain-independent design knowledge. This approach is based on the belief that designing in different disciplines has much in common, that domain independence is necessary for multidisciplinary teams, and that domain independence can generate new views on the traditional design process within a given discipline.

One of the similarities of designing in different disciplines is the importance of the concept of a design situation. A design situation is defined as the state of the product being designed, of the design process, and of the design context at a particular moment. The goal in this research is to develop support for aiding designers with regular reflection on the design situation they are in. This reflection should improve the design process and its results.

Research method
An explorative study including an empirical research, a literature study, as well as the development of support for designers is performed. To explore characteristics of design situations in practice, case studies in different disciplines are compared in a cross-case analysis for similarities and differences. The chosen disciplines are Architecture, Mechanical Engineering, and Software Engineering. The results of the cross-case analysis and the literature study are used to develop support. A first evaluation of this support with the designers of the case studies is executed.

Results
One possible view on designing is elaborated in a design philosophy. This view is based on the concept of state transition systems. The design philosophy consists of a set of concepts and definitions useful to give a domain-independent description of the design process, namely as a sequence of state transitions. The design philosophy is represented in a design model.

The descriptive knowledge of the design philosophy is used to develop design support, which can be seen as prescriptive knowledge. A particular design situation can be defined by the set of properties of the product being designed, the design process, and factors in the design context influencing both. To reflect on a design situation, designers are supported to make a description of the design situation. Three kinds of support are developed: a design frame, a design method, and a design tool.

The design frame is developed to support the description of a design situation. It is an aid to structure the properties and factors of a design situation. The design method supports regular reflection on a design situation. A checklist can be used to make an inventory of important properties and factors at a certain moment. This checklist, together with the design frame, can help designers to make a description of the design situation. The concept of design sessions is introduced to reflect regularly during a design process, namely at the beginning and end of important design sessions. The design tool is a software tool that supports the use of the design method and offers possibilities for the analysis of design situations. It is a prototype consisting of a database to store properties and factors and of a user interface to describe a design situation and to execute queries.

Contribution
The contribution of this explorative study can be found in the consistent elaboration of one vision on designing and in the coherent support for reflecting on design situations, based on literature and design practice. Possible users of this knowledge are designers, design students, and researchers in different disciplines. In order to be useful, the domain independent support must, of course, be tailored to the specific needs of the different disciplines. More empirical research is necessary to validate, verify, and improve the results.

Supervisors
− prof.dr.dipl.ing. D.K. Hammer (computer science, EUT)
− prof.dr.ir. P. Kroes (philosophy, TUDelft)
− prof.dr.ir. J.E. van Aken (management, EUT)

Planning
Started September 1996
First confrontation with design practice and design education: February 2000
Finishing writing thesis: June 2000
Promotion: September 2000

Table 3.2: Project Description sent to the designers.

3.2 Confrontation

To get feedback from the expert designers, I explained each result briefly to them. For that reason, I used the documents as shown in Tables 3.3 to 3.13. These documents are summaries of the results of the performed research.

Relevant, useful?
Design Model

Design situation on t(i)

Change in design context

Interaction

Design activity in design task

State of context
State of product
State of process

Design situation on t(i+1)

State of context
State of product
State of process

towards

Designing is the act of transforming the state of the product being designed or of the design process into another state in the direction of the design goal, by transforming a representation of the product or of the design process. Sequence of state transitions
Properties and factors

Table 3.3: Design philosophy.

Design frame: three dimensions
Level

Property/Factor 1

Level 1

Property/Factor 2.1
Property/Factor 2.2
Property/Factor 2.3

Level 2

Property/Factor 3.1
Property/Factor 3.2

Level 3

Table 3.4: Design frame (1).
Table 3.5: Design frame (2).

Table 3.6: Design method (1).
Table 3.7: Design method (2).
Figure 3.8: Prototype software tool (1).

Figure 3.9: Prototype software tool (2)
Table 3.10: Prototype software tool (3).

Figure 3.11: Prototype software tool (4).
Figure 3.12: Prototype software tool (5).

Figure 3.13: Prototype software tool (6).
3.3 Processing of the data

During the interviews, the feedback received from the expert designers was written down in Dutch. Afterwards, the feedback was summarised and typed, also in Dutch. Then, the summaries were translated to English. These summaries were used as a basis for the analysis and synthesis of the feedback of all expert designers. The transcription scheme to process the data was structured following my four main results (a design philosophy, a design frame, a design method, and a prototype software tool) and included a section for some comments. Different versions of the transcribed data can be found in Section 5.1. Remarks made by the expert designers that did not concern topics of the transcription scheme were not added in the descriptions of Chapter 5. The documents referred to by the expert designers during the confrontation have also not been analysed. The results of the processing process can be found in Chapter 6.
4 Detailed protocol for the junior designers

The goal of this chapter is to offer detailed information about the protocol of the junior designers. Section 4.1 discusses the preparation of the confrontation of the results of the Ph.D. project with the junior designers. In Section 4.2, the documents used for the confrontation are discussed. Section 4.3 discusses the processing of the data.

4.1 Preparation of the confrontation

To prepare the confrontation, I made a detailed planning of the day. I also made reservations for lunch, for coffee and tea, for a nice room, and for several laptops. I prepared slides and handouts to explain the goal of the design day and the results of the project to the designers. Documents explaining the design method and design tool that could be used by the designers were made (for the design method: forms, checklists, and an example of the design of a garden house; for the prototype software tool: a user manual, screen dumps, and notes). The implementation of the tool has been finished and some examples and templates were developed. Finally, question lists for the evaluation of the design method and prototype software tool were made and topics for a final group discussion were defined.

The designers were sent several documents. A first time, I sent them an introductory document (see Table 4.1), an abstract of the Ph.D. thesis, and information about the design day (see Table 4.2). The latter document included a preliminary planning of the day and an explanation about the design task. The document that was sent to the designers a second time (see Table 4.3) included a final planning of the day and a list of the participants. I did not give information about the design method and tool beforehand so that they could start open-minded.

I asked the designers to choose one design task they could work on for a whole day. The choice for a design task was discussed between the designers and myself. Requirements for the design task were the following: the task must include a problem that includes several aspects (for example, efficiency and user aspects) and that can be elaborated on several levels of abstraction, that involves several stakeholders, and that concentrates on several processes of the product lifecycle. It was even better when the task includes a non-trivial problem (a conflict or dilemma). It had to be possible to work on the problem without using domain-specific tools. It could be the beginning of a new design task of the continuation of an existing task. The task did not have to be finished at the end of the day.

Isabelle Reymen
Stan Ackermans Instituut
Technische Universiteit Eindhoven
telefoon: +31 (0)40 247 2749; fax: +31 (0)40 246 8508
prive: +31 (0)40 243 6568 (‘s avonds)
e-mail: isabelle @ win.tue.nl
homepage: http://www.win.tue.nl/cs/tt/isabelle/


Beste ontwerper,
Als AiO bij het SAI ben ik van plan om de tweede helft van dit jaar te promoveren met een proefschrift over ontwerpen. Omdat ik de ontwikkelde ideeën graag nog wil toetsen op relevantie en bruikbaarheid voor de ontwerppraktijk, wil ik, indien mogelijk, hiervoor een beroep op u doen.
Mijn onderzoek is een verkennende studie die vertrok van observaties in de praktijk en in de literatuur en resulteert in domein onafhankelijke ondersteuning voor ontwerpers in de praktijk. De studie omvat de volgende vier resultaten: ontwerpfilosofie, een ontwerpraamwerk, een ontwerpmethode en een ontwerpgereedschap. In bijlage vindt u een samenvatting van mijn onderzoek.

In de eerste helft van februari 2000 ben ik van plan een ontwerpdag te organiseren waarop u samen met andere (ex) AiO’s bij het SAI wordt uitgenodigd om de ontwerpmethode en het ontwerpgereedschap te testen. De dag zal bestaan uit het uitvoeren van een (zelfgekozen) ontwerpopdracht met behulp van de methode en het gereedschap en uit het geven van feedback hierop. Hiervoor kiest u een concreet ontwerpprobleem dat in de huidige praktijk nog (deels) opgelost moet worden. Tijdens deze dag heeft u ongeveer 4 uur om verder te werken aan het probleem. Van te voren kunnen we over de keuze van het probleem even van gedachte wisselen. Meer informatie over deze ontwerpdag vindt u in bijlage 2. Gnaag geef ik u nog meer informatie over deze ontwerpdag.

Gelieve me even te laten weten of u bereid bent aan deze dag deel te nemen. Reeds bij voorbaat dank! Als u (nog andere) ontwerpers weet die bereid zijn mee te doen aan deze dag, mag u deze namens mij ook van harte uitnodigen. Laat het me dan wel even weten. U kan ook met een (deel van een) team deelnemen. Suggesties voor de opzet van de ontwerpdag zijn eveneens welkom.

Met vriendelijke groeten,
Isabelle Reymen

Bijlagen:
1: samenvatting van het onderzoek (see abstract)
2: informatie ontwerpdag februari 2000

---

**Table 4.1: Introductory document sent to the designers (first time).**

Informatie Ontwerpdag Februari 2000

1 Voorlopig Programma
9.00u – 9.15u: ontvangst/ koffie/ kennismaking
9.15u – 9.30u: presentatie ontwerpmethode
9.30u – 11.30u: ontwerpsessie 1 (gebruik van ontwerpmethode)
11.30u – 12.15u: evaluatie ontwerpmethode:
12.15u – 13.15u: lunch
13.15u – 13.30u: presentatie en demonstratie ontwerptool
13.30u – 15.30u: ontwerpsessie 2 (gebruik van ontwerptool)
15.30u – 16.15u: evaluatie ontwerptool:
16.15u – 17.00u: groepsdiscussie
uitwisselen ontwerprvaringen uit dagelijkse praktijk
afsluiten (hapje en drankje)
locatie: TUEindhoven, gebouw en lokaal nog te bepalen
Lunch worden u aangeboden.

2 Ontwerpdracht
Individuele opdracht, door de ontwerper zelf te kiezen. Bij voorkeur een ontwerpprobleem dat zich voordoet in het werk van de ontwerper en dat nog (deels) opgelost moet worden. Hieraan moet de hele dag gewerkt kunnen worden. De keuze van het probleem kan worden gemaakt in overleg met Isabelle.

---

**Table 4.2: Information about the design day sent to the designers (first time).**

Ontwerpdag 17 maart

Programma
9.00u - 9.15u: ontvangst/ koffie/ kennismaking
9.15u - 9.30u: presentatie ontwerpmethode
9.30u - 11.30u: ontwerpsessie 1 (gebruik van ontwerpmethode)
11.30u - 12.15u: evaluatie ontwerpmethode
12.15u - 13.15u: lunch
13.15u - 13.30u: presentatie en demonstratie ontwerptool
13.30u - 15.30u: ontwerpsessie 2 (gebruik van ontwerptool)
15.30u - 16.15u: evaluatie ontwerptool
16.15u - 17.00u: groepsdiscussie
uitwisselen ontwerpervaringen uit dagelijkse praktijk
afsluiten met een drankje

Locatie
EESI (Eindhoven Embedded Systems Institute)
Technische Universiteit Eindhoven, Laplacegebouw, Zuid-ingang: De Zaale
Plannetje: http://www.win.tue.nl/~eesihome/dutch/kantooradres.html

Deelnemers

<table>
<thead>
<tr>
<th>DEELNEMER</th>
<th>DISCIPLINE</th>
<th>HUIDIGE WERKKRING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marcel Renkens</td>
<td>Werktuigbouw (gepromoveerd op proefontwerp, mechatronia)</td>
<td>Philips Natlab, CFT</td>
</tr>
<tr>
<td>Albert Hofkamp</td>
<td>Informatica (promotie op proefontwerp binnen werktuigbouw)</td>
<td>TUE</td>
</tr>
<tr>
<td>Wilbert Alberts</td>
<td>Informatica (gepromoveerd op proefontwerp binnen werktuigbouw)</td>
<td>ASML</td>
</tr>
<tr>
<td>Raymond Habets</td>
<td>Informatica (promotie op proefontwerp binnen elektrotechniek)</td>
<td>TUE, St- Catharine ziekenhuis</td>
</tr>
<tr>
<td>Nicole Segers</td>
<td>Bouwkunde (promotie op proefschrift over ontwerpondersteuning)</td>
<td>Bouwkunde TUE, Calibre</td>
</tr>
<tr>
<td>Sander de Jonge</td>
<td>Bouwkunde (promotie op proefontwerp)</td>
<td>Bouwkunde TUE</td>
</tr>
<tr>
<td>Bart van den Hoge</td>
<td>Industrieel ontwerpen in de praktijk</td>
<td></td>
</tr>
</tbody>
</table>

Ondersteuning
Elisabeth Melby en Isabelle Reymen

Table 4.3: Information about the design day sent to the designers (second time).

4.2 Confrontation

A detailed planning of the design day is given in Table 4.4. I brought enough paper, pencils, sheets, and copies of all documents for the designers to the room used for the design day. Elisabeth, the programmer who assisted me, installed the software on the laptops.

<table>
<thead>
<tr>
<th>Planning design day:</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.00u – 9.15u:</td>
</tr>
<tr>
<td>reception/ coffee/ acknowledgement</td>
</tr>
<tr>
<td>introduction: goal of the day (4 slides)</td>
</tr>
<tr>
<td>9.15u – 9.30u:</td>
</tr>
<tr>
<td>presentation design method (10 slides)</td>
</tr>
<tr>
<td>expectations</td>
</tr>
<tr>
<td>9.45u – 11.45u:</td>
</tr>
<tr>
<td>design session 1 (use of design method):</td>
</tr>
<tr>
<td>observation of designers by Isabelle: measure the duration of each activity</td>
</tr>
<tr>
<td>instruct when to start with reflection</td>
</tr>
<tr>
<td>11.45u – 12.15u:</td>
</tr>
<tr>
<td>evaluation of design method:</td>
</tr>
<tr>
<td>question list</td>
</tr>
<tr>
<td>group discussion</td>
</tr>
<tr>
<td>12.15u – 13.15u:</td>
</tr>
<tr>
<td>lunch</td>
</tr>
<tr>
<td>13.15u – 13.45u:</td>
</tr>
<tr>
<td>presentation and demonstration software tool (5 slides en demo)</td>
</tr>
<tr>
<td>expectations</td>
</tr>
<tr>
<td>13.45u – 15.45u:</td>
</tr>
<tr>
<td>design session 2 (use of prototype software tool)</td>
</tr>
<tr>
<td>observation of designers by Isabelle: measure the duration of each activity</td>
</tr>
<tr>
<td>instruct when to start with reflection</td>
</tr>
<tr>
<td>15.45u – 16.15u:</td>
</tr>
<tr>
<td>evaluation of software tool:</td>
</tr>
<tr>
<td>question list</td>
</tr>
<tr>
<td>group discussion</td>
</tr>
<tr>
<td>16.15u – 17.00u:</td>
</tr>
<tr>
<td>group discussion (1 slide)</td>
</tr>
<tr>
<td>exchange design experiences from daily practice</td>
</tr>
<tr>
<td>closure</td>
</tr>
</tbody>
</table>

Table 4.4: Detailed programme of the design day.
The design day started with a brief introduction during which the goal of the design day was explained. This goal was to obtain feedback about experiences of designers with the use of the design method and prototype software tool. Individual question lists and group discussions (between designers from several design disciplines) offered the desired feedback. The design day consisted of two design sessions in which two subtasks were performed; therefore, the designers were asked to define two subtasks of the chosen design task. Before lunch, during a first session, the design method was used and feedback on the design method was given; after lunch, the prototype of the software tool was tested.

Before the first session started, a general presentation about the design method was given, using the example of a garden house (see Appendix C in [Reymen, 2001a]). After the introduction, the designers were asked to write down their expectations of the design method on a blank A4-paper. (The goal was to capture the designers’ experiences with the design method; these were related to their expectations.) The designers received a copy of the slides of the design method, blank forms, various checklists (including an explanation of the attributes used), and an example of the use of the design method for the case of a garden house. When following the design method, the session had to start with reflection on the complete design situation; therefore, the developed blank forms and the checklists could be used. During the core of the session, the designers could work on their subtask. At the end of the session, they could reflect on changes in the design session, again using forms and checklists. In the mean time, I observed the designers and helped them to use the method. When the session was finished, each designer was asked to evaluate the design method by writing down, on an evaluation sheet, positive and negative experiences on the following topics: general impression, time spent on reflection in relation to the duration of the design session, support offered by the forms and checklists, relevance of the design method, usefulness of the design method, and suggestions for improvement. Therefore, they received evaluation sheets (two A4-papers with boxes as illustrated in Table 4.5); in each box, a question about a positive or negative experience concerning a certain topic was written. On the yellow memos stuck on each box, the designers could write their feedback. Afterwards, all yellow memos were stuck on the black board, clustered in the same categories. The designers came to the blackboard for a group discussion on each topic; their experiences were ranked and the most important experience was chosen. Differences between designers (disciplines) were also discussed. I wrote down the results of the discussion.

After lunch, I presented the ideas of the prototype of the software tool and gave a demonstration of its use. The course of the second session was similar to the course of the first session. Again, the designers had to write down their expectations. They received a copy of the slides of the tool and a manual of the prototype including a general explanation of the screens and buttons and some screen dumps. When following the design method, for which the prototype has been developed, the session had to start with reflection on the complete design situation and on changes between the two sessions. The designers could use the prototype to support their reflection process (I arranged a laptop for each user): add properties and factors and execute specific queries. During the core of the session, they could work on their second subtask. At the end of the session, they could reflect on changes in the design session, again by using the software tool for adding properties and factors and executing specific queries. When the session was finished (after two hours), the designers were asked to evaluate the prototype software tool. Therefore, they received again evaluation sheets (two A4-papers with boxes, as illustrated in Table 4.6) with yellow memos; in each box, a question about a positive or negative experience concerning a certain topic was written. The topics were similar to those for the design method (general impression, time spent using the tool in relation to the duration of the design session, support offered for reflection, relevance of computer support for reflection, usefulness of the tool, suggestions for improvement). During the discussion that followed the individual evaluation, each topic was discussed, based on the yellow memos that were stuck on the black board. I tried to have a real discussion on the concepts of the tool; I was not that much interested in topics about the user interface. Pictures of the group discussion at the end of the second session are given in Figures 4.7 and 4.8.

A final group discussion about the relevance of reflection and the support for a design session was planned. The descriptions and analyses made on paper during the use of the design method were
compared and the experiences of using the design method and the prototype software tool were compared. Also, differences between different disciplines could be discussed and suggestions for improvement were made.

<table>
<thead>
<tr>
<th>General impression: positive</th>
<th>General impression: negative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time spent on reflection in relation to period of design session: positive</td>
<td>Time spent on reflection in relation to period of design session: negative</td>
</tr>
<tr>
<td>Support offered by sheets and checklists (combination of describing and analysing): positive</td>
<td>Support offered by sheets and checklists (combination of describing and analysing): negative</td>
</tr>
<tr>
<td>Relevance of the method: positive</td>
<td>Relevance of the method: negative</td>
</tr>
<tr>
<td>Usefulness of the method: positive</td>
<td>Usefulness of the method: negative</td>
</tr>
<tr>
<td>Suggestions for improvement</td>
<td></td>
</tr>
</tbody>
</table>

Table 4.5: Form for the evaluation of the design method.

<table>
<thead>
<tr>
<th>General impression: positive</th>
<th>General impression: negative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Period using tool in relation to period of design: positive</td>
<td>Period using tool in relation to period of design: negative</td>
</tr>
<tr>
<td>Support offered for reflection: positive</td>
<td>Support offered for reflection: negative</td>
</tr>
<tr>
<td>Relevance of computer support for reflection: positive</td>
<td>Relevance of computer support for reflection: negative</td>
</tr>
<tr>
<td>Usefulness of tool: positive</td>
<td>Usefulness of tool: negative</td>
</tr>
<tr>
<td>Suggestions for improvement</td>
<td></td>
</tr>
</tbody>
</table>

Table 4.6: Form for the evaluation of the prototype software tool.
4.3 Processing of the data

At the end of the design day, I received the following documents of the individual designers: their expectations of the design method and prototype software tool; their evaluations of the design method and prototype software tool (on yellow stickers, stuck on the white board). All the information was written in Dutch. I made myself written notes of the group discussions (in Dutch). I typed all information following the transcription scheme given in Table 4.9. Several versions (see Chapter 5) were made to come to a general description of the feedback of the designers on the design method and prototype software tool (see Chapter 6).
method
  − expectations
  − evaluation sheets
    General impression;
    Time spent on reflection in relation to period of design session;
    Support offered by sheets and checklists (combination of describing and analysing);
    Relevance of design method;
    Usefulness of the design method;
    Suggestions for improvement.

tool
  − expectations
  − evaluation sheets
    general impression
    period using tool in relation to period of design
    support offered for reflection
    relevance of computer support for reflection
    usefulness of tool
    suggestions for improvement

Table 4.9: Transcription scheme.
5 Analysis and synthesis of the feedback

The goal of this chapter is to give insight into the evolution of the processing of the received feedback. Section 5.1 includes several versions of descriptions of the feedback given by the expert designers. Section 5.2 shows the evolution of the analysis and synthesis of the feedback given by the junior designers. The descriptions have no scientific value other than that they illustrate the evolution in processing the raw data.

5.1 Expert designers

The expert designers gave feedback on the design philosophy, the design frame, the design method, and the prototype software tool. For the feedback on the design method and on the prototype software tool, two versions in the processing process are represented. Some parts of the data are written in Dutch.

5.1.1 Feedback of the expert designers on the design philosophy

In general, all experts recognised the concepts of the design philosophy and understood its terminology; the concepts and terminology seem to be domain independent.

To improve my description of design processes, they suggested adding the concepts of risks (uncertainties) and of iterations. The concept of risks can be found in Section 3.3.2 in [Reymen, 2001a]; the concept of iterations is discussed in Section 3.5.1 in [Reymen, 2001a].

The experts stressed that changing desired properties during a design process is common practice. The architects also stressed the importance of the design context and the interaction of designers with the design context during a design process.

The importance of changes and interactions is written down by Henk Döll [LeCuyer (ed.), 1999] as follows: “The problem is constantly revised, reshaped, and reframed through interaction with this complex entity called the client.”.

5.1.1 Feedback of the expert designers on the design frame

General
Koster: the dimensions are abstractions that can be used in a language necessary to understand designers from different disciplines.

Brouwer: How is a general view constructed? Are levels coupled to perspectives and processes?

Level:
van der Sanden asked for the definition of a level: is it meant as the composing and decomposing of a system?
In architecture (Brouwer, Döll), levels are very important. Architects have to look at the overall structure and to the details.
Döll: Levels of abstraction are substantial in architecture. Architects must be trained to think on different levels of abstraction. For example, when an architect works on a high level of abstraction (part of a city), it is also important to consider in detail the functions of the buildings or the compactness of the buildings.

Perspective:
van der Sanden asked for the definition of a perspective: is it meant as different aspects or as different abstractions?
Koster: the most important viewpoint is that of the customer; other viewpoints must be derived from the former.
The importance of perspective is subscribed by Brouwer: he calls it ‘study of aspects’.
Brouwer: a designer may not concentrate on one aspect, in a design, always multiple aspects are important.
Time:
Koster: attention to the order of phases in the product lifecycle is important. At this moment, the designers at CFT do not take the recycling and decommissioning into account. Tools could help with this.

Underpinning
Kruithof: Are these the only dimensions?
van der Sanden: a possible reference that can justify the three dimensions (general system theory)

Verschillende stromingen:
− Ontologisch (beschouwen, empirisch): het ken-object is het systeem
− Conceptueel: drie manieren om op te splitsen: Sub-systeem, clusters, aggregatie: delen aggregeren Aspect-systeem: uit alle objecten die vanuit een bepaald aspect zichtbaar zijn moet het volledige systeem begrijpbaar zijn (min of meer onafhankelijk)
− Faze-systeem: verband tussen twee toestanden: enkel op gezette tijden kijken; de tussenliggende toestanden doen er niet toe
  Drie assen: objecten (niveaus), relaties (kleur van de relaties: aspecten), gedrag in de tijd (tijd)

Relevance
Koster: the dimensions are abstractions. Abstractions, together with representations are very important and their importance will increase when everything must be communicated faster and more efficient.
Brouwer: Not only designers, but also the commissioners have to see the importance of dimensions. Already at the beginning of a design project, it is important to look at different levels of abstractions, different aspects and different processes in the product lifecycle. Commissioners must give designers to do so. Usually, this time will be gained and a better design results.

Usefulness

5.1.2 Feedback of the expert designers on the design method

5.1.2.1 Version 1

While speaking about my design method, I received the following information from the experts in practice:

Goal of method: registration of design process? Reference to design history systems. (Koster)

Reflection and feedback are very important. Certain aspects (mainly the production methods and the market) are taken into account only too late in the design process. This results in many problems during the implementation process: 30 till 40% of the design has to be redone. The latter consumes a lot of time and money and results in a lot of misery. (Brouwer)

Moments for reflection mentioned by the experts:
Not formalised:
− At the end of a day (van der Sanden, Döll)
− Regular evaluation of satisfaction of client by employees working at client (van der Sanden)
− Regular demand of company to employees working at client: something interesting learned? (van der Sanden)
− Awareness of mental state of designer (context of discovery: inventory, diagnosis, design) (van der Sanden)
− Possibility: every week briefing and de-briefing about design situation (awareness of product being designed, design process, and design context becomes routine) (van der Sanden)
− Personal reflection: every evening think about what will do the next day, make a to do list (van der Sanden)
− Personal reflection: every evening think about achievements and progress of the day People who do not so, will likely not be triggered by a method to do so. (Kruithof)
− Every week demand of state report of project leader to employees working externally. (Kruithof)

Formalised:
− Evaluation at the end of a project (van der Sanden)
− Scenario-telling: telling stories about the consequences of current decisions for the future. These stories are kept in mind and improve your sensitivity (performed at Shell). (van der Sanden)

Documentation:
− Regular reports for client (van der Sanden)
− Reports made at a milestone (drawings, calculations, less important decisions) (Koster)
− State reports, for regular meetings (Kruithof)
− Internal (in company) and external (with customers, other stakeholders) (van der Sanden, Döll)
− Van der Sanden mentioned the difference Panfox make between the documentation of the context of justification and the context of discovery.
− Only important decisions (including rationale and alternatives), on key moments. Find back information! (Koster)
− State reports: every two months (Kruithof)

Individual and group reflection (van der Sanden)

Sessions
The term ‘session’ recalls group sessions.
Kind of sessions:
− progress (time and money) and contents (plan, techniques) meetings (Koster, Döll) (in complex projects)
− regularly and incidentally meetings (Koster, Kruithof)

Conclusion: different periods between different kind of reflection
− Learning sessions: not too often: Non trivial analyses consume very much time. When these are executed too often, it becomes a ritual, people omits the problems and do not learn anything from it. (van der Sanden)
− Once a week: briefing, de-briefing (van der Sanden)
− Every evening: personal reflection (individual) (van der Sanden)
− Every hour: awareness of mental state (individual) (van der Sanden)

Koster called reflection a retrospective moment.
Base retrospective moments on planning of project instead of regularly in time. During certain phases, reflection is not meaningful, because only less important decisions are taken. These decisions are laid down in reports. Registration of important decisions, for example, integration of several components, together with alternatives and rational, is very useful. The decisions taken earlier in a design process are important when new decisions are taken that are related to consequences of these earlier decisions. (Koster)

Brouwer offers the reference Crane.

Application of design method in architecture: in quality system
Both architects suggested to incorporate the design method in the qualitative procedures of an architects office. Only then, architects are forced to work methodical (make documentation and check things). This is the only way to get these results. (Brouwer)

In the quality handbook that is been made by Mecanoo is described what must be done in each phase. The role of the project leader is described. The handbook consists of checklists in which is described all documents that are needed, the parties with which a discussion is necessary, and which calculations must be made. The project leader must check the lists. (Döll)

A good balance is necessary between structured working and working too structured. The starting position is that you work in a professional organisation with high-qualified persons. These must be able to follow certain procedures without being controlled on the execution of these procedures. For project leaders, it is important what they do and not how they do it. The quality handbook must be used flexible: certain aspects are not yet important in a specific phase in a specific project. (Döll)

5.1.2.2 Version 2

Add:
The time spent on reflection and learning must offer a designer something. Three times, it does not offer anything, the fourth time it does. Once the goal of reflection is seen, people do it.

I received the following information from the experts in practice. In general, Koster noticed that the goal of the design method is related to a registration of the design process? He also referred to design history systems. Brouwer found that reflection and feedback are very important. Certain aspects (mainly the production methods and the market) are taken into account only too late in the design process. This results in many problems during the implementation process: 30 till 40% of the design has to be redone. The latter consumes a lot of time and money and results in a lot of misery.

Sessions
The term ‘session’ recalls group sessions.
Brouwer offers the reference Crane.
Kind of sessions:
- progress (time and money) and contents (plan, techniques) meetings (Koster, Döll) (in complex projects)
- regularly and incidentally meetings (Koster, Kruithof)
- internal (in company) and external (with customers, other stakeholders) (van der Sanden, Döll)

Reflection in the current design practice

<table>
<thead>
<tr>
<th>I/G</th>
<th>F/N</th>
<th>D/N</th>
</tr>
</thead>
<tbody>
<tr>
<td>each hour</td>
<td>I</td>
<td>N</td>
</tr>
<tr>
<td>every evening</td>
<td>I</td>
<td>N</td>
</tr>
<tr>
<td>every evening</td>
<td>I</td>
<td>N</td>
</tr>
<tr>
<td>every week</td>
<td>I</td>
<td>F</td>
</tr>
<tr>
<td>regular</td>
<td>I</td>
<td>N</td>
</tr>
<tr>
<td>regular</td>
<td>I</td>
<td>N</td>
</tr>
<tr>
<td>regular</td>
<td>I</td>
<td>F</td>
</tr>
<tr>
<td>at a milestone</td>
<td>G</td>
<td>F</td>
</tr>
<tr>
<td>every three months</td>
<td>G</td>
<td>N</td>
</tr>
<tr>
<td>at the end of a project</td>
<td>G</td>
<td>F</td>
</tr>
</tbody>
</table>

I/G: INDIVIDUAL OR GROUP
F/N: FORMALISED OR NON-FORMALISED
D/N: DOCUMENTATION OR NOT

- Van der Sanden mentioned the difference Panfox make between the documentation of the context of justification and the context of discovery.
- Individual and group reflection (van der Sanden)

Possible application of the design method in the design practice

- Learning sessions: not too often: Non trivial analyses consume very much time. When these are executed too often, it becomes a ritual, people omits the problems and do not learn anything from it. (van der Sanden)
- van der Sanden sees possibilities for a briefing and de-briefing about the design situation every week. He thinks that awareness of the product being designed, the design process, and the design context becomes routine when these reflections are executed often.
- Koster called reflection a retrospective moment. For him, retrospective moments can best be based on the planning of a project instead of regularly in time. During certain phases, reflection is not meaningful, because only less important decisions are taken. These decisions are laid down in reports. Registration of important decisions, for example, integration of several components, together with alternatives and rational, is very useful. The decisions taken earlier in a design process are important when new decisions are taken that are related to consequences of these earlier decisions. Finding back information is also important.
- In architecture: in a quality system. Both architects suggested incorporating the design method in the qualitative procedures of an architect’s office. Only then, architects are forced to work methodical (make documentation and check things). (Brouwer) In a quality handbook made by Mecanoo, it is described what must be done in each phase. The handbook consists of checklists that describe all documents that are needed, the parties with which a discussion is necessary, and which calculations must be made. The role of the project leader is to check the lists. To make such a quality handbook, it is necessary to keep in mind a good balance between structured working and working too structured. The starting position is that you work
in a professional organisation with high-qualified persons. These must be able to follow certain procedures without being controlled on the execution of these procedures. For project leaders, it is important what they do and not how they do it. The quality handbook must be used flexible: certain aspects are not yet important in a specific phase in a specific project. (Döll)

5.1.3 Feedback of the expert designers on the prototype software tool

5.1.3.1 Version 1

Van der Sanden: In the existing support in practice (development support: how to organise a process; modelling approach: to represent reality; management approach: controlling), learning from earlier experiences is no part of.

A user must make himself familiar with the design tool by means of a training. Once familiar, the user can lay down very vast and the ideas of the user can be checked very fast.

Possible things to lay down:
- How think about something
- Important decisions
- Ideas
- Planned actions for next day (easy to enter and structure)
- List of risks (can be part of the checklist)
- Link to data of the product (with html?)

Possible things to control with the tool:
- Influence factors on a goal
- Check what is asked: no things forgotten?

Structure of data in the tool: start with no structure; when the number of data becomes too high, add some kind of structure. The users define all categories of the structure such that all data can be found back later on. Users need training to choose good definitions.

Related: PSP, Damming: plan, do action, …

Koster:
The tool can be used for concurrent engineering. Others can find back the information.
The tool must be tested in complex projects with multiple disciplines.

Kruithof:
When this kind of tools is obliged in practice, the motivation of the designers is very little. Technicians like to make their own tool. Technicians already think abstract… The most important links between facts are already in their heads. Just entering data in the tool offers a designer not many added value in his perception. There is also a natural resistance against entering a lot of data. Only when the designer met some problems, such a tool will be appreciated. People see then the necessity to lay down relations, because they forget these when they need them after one year.

Brouwer:
The biggest problem of such a tool is how oblige people t think about certain aspects and not only mark the aspect. The certainty of looking at an aspect must be arranged.

Perhaps, also a tool must be made for the commissioner, who must be convinced that the design phase is very important. More money is necessary for this phase.

Döll:
The idea of the checklist can be elaborated for the tool. A link can be made with a quality handbook. Process support has much potential! An important requirement for the use of the tool is that information can be entered very fast. The tool can give the user a signal when he has forgotten something.

Isabelle: With software, a checklist can easily be made specific for a project (copy and past of a general checklist). The tool can show what must be done. The checklist can include things about the product being designed, the design process, and the design context.

A distinction between current and desired properties is difficult to make. You can never say which property is completely designed. All decisions are interwoven.
During a design process, millions of things are important. Decisions about all these cannot all be described and underpinned. Many decisions are taken implicitly, only a few are taken explicitly. Designers are forced to think about the arguments for underpinning their decisions when they have to give a presentation for several groups. Starting from the problem, arguments can be given for the way the problem is solved. At that moment, a database could be useful.

All experts focussed on the checklist.

### 5.1.3.3 Version 2

Suggestions from the expert designers to elaborate the prototype are described below.

The tool can be used for **learning**. Van der Sanden mentioned that learning from earlier experiences is not yet supported in practice. Existing support concentrates on development (how to organise a process), modelling (how to represent reality), and management (how to control a process).

The tool can be used for **process support**. Döll qualified process support as highly potential. For architecture, a link can be made with a quality handbook. The idea of a checklist can be elaborated; with software, a checklist can easily be made specific for a project (copy and past of a general checklist). The checklist can include things about the product being designed, the design process, and the design context. The tool can show what must be done.

The tool can be used for **concurrent engineering**. Koster sees possibilities for all parties to find back information of the project in the database of the tool.

The tool can be used for **documenting and control**. Van der Sanden mentioned possible things to lay down: important decisions, ideas, how a user thinks about something, planned actions for the next day (requirement: easy to enter and structure), risks (can be part of the checklist), and links to data of the product being designed (with html?). Possible things to control with the tool are checking the influence factors on a goal and checking if no things that are asked are forgotten.

However, Döll mentioned that during a design process, millions of things are important. Decisions cannot all be described and underpinned. Many decisions are taken implicitly, only a few are taken explicitly. Designers are already forced to think about the arguments for underpinning their decisions when they have to give a presentation for several groups: starting from the problem, arguments can be given for the way the problem is solved. At that moment, a database could be useful.

Van der Sanden suggested starting with no structure of the data in the tool. When the amount of data increases, some kind of structure can be added. The users must define all categories of the structure such that all data can be found back later on.

For Döll, an important requirement for the use of the tool is that information can be entered very fast. The tool can also give the user a signal when he has forgotten something. He also mentioned that it is difficult to make a distinction between current and desired properties. You can never say which property is completely designed; all decisions are interwoven.

Van der Sanden mentioned that a user must make himself familiar with the design tool by means of a training. Once familiar, the user can lay down very fast and the ideas of the user can be checked very fast. A user also needs a training to choose good definitions.

Kruithof said that when this kind of tools is obliged in practice, the motivation of the designers is very little. Technicians like to make their own tool and technicians already think abstract. The most important links between facts are already in their heads. Just entering data in the tool offers a designer not many added value in his perception. There is also a natural resistance against entering a lot of data. Only when a designer met some problems, such a tool will be appreciated. People see then the necessity to lay down relations, because they forget these when they need them after one year.

Brouwer said that the biggest problem of such a tool is how oblige people to think about certain aspects and not only mark the aspect. The certainty of looking at an aspect must be arranged.

Koster added that the tool must be tested in complex projects with multiple disciplines.

Related: PSP, Damming: plan, do action, … (van der Sanden)
5.2 Junior designers

The junior designers gave only feedback on the design method and the prototype software tool. For the feedback on the design method, two versions, and for the feedback on the prototype software tool, three versions in the processing process are given.

5.2.1 Evaluation of the design method by the junior designers

5.2.1.1 Version 1

| General impression: | Positive: |
| Reflection is relevant because it can make a designer aware of the steps he takes, of the design situation, and of the working method; it brings order in a chaotic process; asks questions to think about; confronts with very concrete aspects like perspectives, timing-aspects, and relations; learn shortcomings. clear idea about state |
| Useful in big organisations |
| Negative: |
| The terminology in the design method does not fit to the terminology used by the designers; classification following attributes is difficult; reflection once during a design session is enough; too much administration of information; too much sheets, terms, and definitions; learning time is needed. |

| Time spent on reflection in relation to period of design session: | Positive: |
| Depends on product, requirements from the market, and the throughput time; optimal 10% reflection and 90% design; think about design process is sometimes more important than separate design activities (the design process gives an overview). faster when known with terminology; |
| Negative: |
| Maximal once a day, otherwise it consumes too much time; spent 70% reflection, 30% design; reflection took too long, possibly caused by lack of experience; time for reflection took longer than expected |

| Support offered by sheets and checklists (combination of describing and analysing): | Positive: |
| The general goal is clear; the example of the garden house offers more insight into the goal of the design method; gives a good overview; gives more confidence in the completeness; availability of information is positive; describing all background information is surprising. |
| Negative: |
| Explanation based on real case from design practice is more valuable; more explanation about terminology is necessary to fill in matrix; more examples are necessary; forces to write down very specific information: leaves little freedom; too extended; the sheets must be structured in a different way for specific phases; lack of domain specific questions; no fitting of domain. |

| Relevance of design method: | Positive: |
| The design method offers an overview; helps for awareness; good for personal process; offers opportunities to define and improve process; when the design method is applied well, can work more directed; especially useful in the beginning phase of design and research; is directed towards a continuous improvement of quality and comparison with other stadia of the process (relative judgement). |
| Negative: |
| Difficult to sell to management; no no visible or measurable effect on throughput time; it may not cost too much; in certain phases less or not necessary; too abstract?; balance between fixed scheme and creative process. |

| Usefulness of the design method: | Positive: |
| Handle; overview of situation; design method is (too) general; gives an overview; comparison of present with history and future is important; good documentation of projects state; looking back in gives again inputs for problems that were forgotten. |
| Negative: |
Too much paper to find anything back; too much administration; not specifically focussed on disciplines; idea for a relation can be can clear, this can cause unclear, vague, or irrelevant reflection; find data; the current method not yet useful for my current situation; find meaning of attributes is not handy; too much to write down.

**Suggestions for improvement:**
- Decrease the number of sheets; design more ‘hard’ check lists; limit an example to one domain; translation to specific disciplines, celebration of specific tasks necessary and important; more compact, focused on one discipline, clear overview; as administration; should be adaptable in time; personal checklists; terminology more clear for its discipline; explanation based on an example; use the method in bed design process or more than one month.

**Expectations of method:**
- There is need for a design method that orders and makes available all relevant things around and about your design.
- When understand terminology, will give advantages when use automatically.

Looking back on design process: design more aware

Couple reflection with evaluation of product and process

5.2.1.3 Version 2

**General impression:**
The general goal of the design method was clear to the designers. The designers also had a clear idea about the concepts of the design philosophy (state, design situation, etc.). The example of the garden house was useful to offer more insight into the goal of the design method. However, an explanation based on a real case from design practice would be more valuable.

The designers wrote down that reflection is relevant because it can make a designer aware of the design situation, of the steps he takes, and of his working method. The need for a design method that orders and makes available to a designer all relevant things around and about a design was also uttered. One designer mentioned that, when the criteria for evaluation are unclear, this can cause unclear, vague, or irrelevant reflection.

Almost all participants mentioned a same characteristic of the design method, namely that it offers an overview (of the design situation, of the design process). Other characteristics of the design method mentioned by the designers are the following:
- the design method helps for awareness;
- the design method asks questions to think about;
- the design method confronts with very concrete aspects like perspectives, timing-aspects, and relations;
- the design method forces to learn from shortcomings.
- the design method helps to work more directed;
- the design method brings order in a chaotic design process;
- the design method offers opportunities to define and improve the design process;
- the design method is directed towards a continuous improvement of the quality and a comparison with other stadia of the process (relative judgement). The comparison of the present with history and future is important;
- the design method offers a good documentation of the project state;
- the availability of information is positive;
- the design method gives more confidence in the completeness of the information;
- describing all background information is surprising;
- looking back gives input for problems that were forgotten.

**Handle**
The design method is especially useful in the beginning phase of design and research projects. In the current form, however, the method is not yet useful in design practice. At this moment, it is difficult to sell the design method to the management because no visible or measurable effect on throughput time can be shown. Only when the concepts and terminology of the design method are understood and used automatically by a designer, it can be clear for him that the method will give advantages.

A negative aspect of the design method mentioned very often by the designers is that the design method was presented very general and not yet focussed on a specific discipline. Making the translation of the terminology (the attributes) into the designers disciplines, was experienced as difficult. Also, no domain specific questions were included in the checklists. More examples are necessary to fill out the general sheets.
The design method also asked too much administration of the designers and resulted in too much paper to find anything back. The design method forces designers to write down very specific information and leaves little freedom. A balance must be found between a fixed scheme and a creative process. The sheets must also be flexible in use: a different structure for specific phases would be likely. Reflection on the design process is sometimes more important than reflection on separate design activities because the design process gives an overview.

**Time spent on reflection in relation to period of design session:**
The designers mentioned that the time spent on reflection during a design session depends on the product being designed, requirements from the market, and the throughput time. An optimal proportion between reflection and design was stated at 10% for reflection and 90% for design. Reflection is executed faster when the terminology is known better. It is also said that reflection once during a design session is enough. Others said that once a day is enough, otherwise, it consumes too much time. The designers estimated that they spend on the design day 70% of their time to reflection and 30% to design. The time for reflection took longer than expected, possibly caused by the lack of experience with the design method. Some learning time is needed to use the design method efficiently.

**Suggestions for improvement:**
The designers suggested the following improvements:
- give an explanation based on an example in one domain;
- make the design method more compact (decrease the number of sheets, include less administration);
- focus on one discipline and make translations of the terminology to specific disciplines (domain specific sheets and checklists);
- make the checklists and sheets adaptable in time and adaptable for a specific designer;
- test the method in a design process taking more than one month.

In the discussions, the following things are also mentioned:
- the concepts of the design method are useful. The form and elaboration of the current method, however, are not yet good enough. The elaboration is important for concrete use in practice.
- documenting the terminology and definitions once at the beginning of a project (with SHEET A), is regarded as very useful. It must be possible to order these definitions in a different way during the course of a design process.
- documenting what is done and which problem is solved, at the end of a session, is very useful;
- Is the method a design method or not: does it sustain or guide the design process? Perhaps, it is a frame for sustaining.
- It is maybe not necessary for reflection to write down a lot of information. Documenting has several negative aspects: the information written down is not only for yourself whereas reflection is personally; there is a problem of consistency and completeness; and it is difficult to find back information.

I observed myself the following things. The attributes in the sheets must be placed in another sequence. The subject-attribute is the most important and must be placed in the first or second column. Possibly, the sheets can be pre-structured for properties about the product being designed, properties about the design process, and factors in the design context (one sheet can be divided horizontally in three parts).

It struck me that the designers with a computing science background had less problems with the general terminology. The latter also offered me a reference to personal software process (PSP), which is quality oriented and related to the design method.

A checklist for certain discipline in a certain company is useful when many analogous projects are executed. The checklists can then be reused. This is the case in bigger organisations. In small companies, like the one represented by the two industrial designers, a checklist can be made for each project. This checklist can be used to get an overview.

### 5.2.2 Evaluation of the prototype software tool by the junior designers

#### 5.2.2.1 Version 1

**Expectations**
Lay down structured decisions, constraints, status, and progress of a project.
Search in, control, overview of complete design process.
Process aspects can be printed, out of different databases
Only actions with a date (overview of decision moments)
Overview of problems and solutions
Overview of context changes
Easy entry and access
Customisability

**General impression**

**Positive**
The tool is less imperative. The predefined values function as examples of answers. Easy to edit information. Interesting for bigger organisations in which many people are involved. Useful for administration of the design process. Has potential value. Simplifies the administration.

**Negative**
The design tool asks too much work. The prototype does not offer an overview (screen is too small). It is mainly a tool for data processing and fastening down. Does not give a good overview of underlying relations. Is automatizing the design method a step forward? The user interface is not clear.

**Period using tool in relation to period of design**
A reasonable (too much) proportion between period using tool in relation to period of design. Copy, paste, and link functionalities are desirable. The prototype is difficult for navigating.

**Support offered for reflection**
Compared to handwriting, the information is better readable on a computer. A good insight into the relations can be obtained. It is possible to get an overview. Possibility to print overview for each subject is desirable. Structuring of the information is desirable. It must be made useful for discussion between different parties. A list of decisions is important. At this moment, the current prototype is more a managing than a reflection tool. The tool offers mainly support to write down what you did instead of being a stimulus for a future design task. Reflection is not clear.

**Relevance of computer support for reflection**
The prototype aids not to forget important things. Process control or monitoring is important for an office manager. The prototype is not a stimulus for the real design activity (represent a vision in a model, drawing, etc.). Just computer support is not necessary for reflection.

**Usefulness of tool**
Process monitoring and collaboration are positive. The tree is a useful structure. A disadvantage is that no specific structure is made for relations. The tool asks too much work. The lack of overview makes the tool less useful than the paper version.

**Suggestions for improvement**
- A more modular structure
- Link with existing tools
- Carry through the consistency checks
- Add a form editor
- Implement actual/obsolete with a radio button
- (More) Graphical visualisation
- Link with text documents, drawings, animations
- Overview
- Drag and drop
- Different graphical representation for structure based on product being designed, design process, and design context.

5.2.2.4 Version 2

The second version of the evaluation of the prototype software tool consists of a description of the feedback given by the junior designers and of my notes made during the discussions with the junior designers.

a) Feedback written down by the junior designers
The junior designers judged the prototype as having some potential value. They evaluated the prototype as follows. At this moment, the current prototype is more of a managing than a reflection tool. It is mainly a tool for data processing and documenting. The tool offers mainly support to write down what a designer does instead of being a stimulus for future design activities. The tool is useful for administration of the design process. Process control or monitoring is important for an office manager. The prototype can also be interesting for bigger organisations in which many people are involved.

There was no consensus about several aspects of the prototype. Some designers mentioned that the tool makes it possible to get an overview, others described that the dimensions of a computer screen make it impossible to get a good overview. It was also said that, on the one hand, a good insight into the relations can be obtained with the prototype; on the other hand, designers mentioned the disadvantages that the prototype does not contain a specific structure for relations and does not give a good overview of underlying relations. The proportion between the period of using the tool in relation to the period of design is judged as reasonable and as too much.

Advantages of the design tool are that the prototype aids not to forget important things and simplifies the administration. Furthermore, it was mentioned that the tree is a useful structure and that the predefined values are good examples of answers.

Many designers agreed that the design tool asks too much work. The user interface is also not clear.

Compared to the design method, the prototype is less imperative. However, the question was asked, is automatizing the design method a step forward? Just computer support is not necessary for reflection. For some designers, the lack of overview makes the tool less useful than the paper version. Compared to handwriting, the information is better readable on a computer; the information can also be edit more easily, but by some designers navigating is judged as more difficult.

The designers suggested the following improvements of the prototype. A more modular structure for the information and a different graphical representation for the structure based on the product being designed, the design process, and the design context. Also, the possibility to print an overview for each subject is desirable. It is important also to include a list of decisions.

The designers also suggested a link with existing tools and a link with text documents, drawings, and animations. The prototype must be made useful for discussion between different parties. Consistency checks can be carried through. Furthermore, a form editor, more graphical visualisation, and copy, paste, drag, and drop functionality can be added. A designer also suggested implementing the actual/obsolete-attribute with a radio button.

<table>
<thead>
<tr>
<th>b) Feedback mentioned during the discussions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Goal</strong></td>
</tr>
<tr>
<td>Tool for orienting, evaluating</td>
</tr>
<tr>
<td>In design practice, this tool easily evolves to a management tool, which is not its goal.</td>
</tr>
<tr>
<td>Two goals: sustain the product and the management process.</td>
</tr>
<tr>
<td>Tool is a side-product of the design method (become rich with the tool!).</td>
</tr>
<tr>
<td>The tool has potential but the form of the tool is not yet good enough.</td>
</tr>
<tr>
<td>The terminology between design method and tool must be consistent.</td>
</tr>
<tr>
<td>Does the use of the computer has advantages? Disadvantages: a computer has a small screen, whereas a designer is used to handle big drawings; the prototype is textual, whereas a designer is used to work graphically.</td>
</tr>
<tr>
<td>Change the idea of filling in cells.</td>
</tr>
<tr>
<td>Tracking or also predict data?</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Comparison with design method</strong></td>
</tr>
<tr>
<td>The terminology between design method and tool must be consistent.</td>
</tr>
<tr>
<td>In the tool more clear description, but a limitation to the number of characters</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Template</strong></td>
</tr>
<tr>
<td>Possibility to change template during the design process (Only addition; when delete items, the data-structure is not consistent anymore)</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Description of design situations</strong></td>
</tr>
<tr>
<td>How come from vague relations to the type specified in the tool? (First, textual, split in cause and reason, enter two properties and or factors, and finally, make the relation.). These are a number of steps.</td>
</tr>
<tr>
<td>Add what changes regarding previous version and the reason of the change to the versions.</td>
</tr>
<tr>
<td>How can two relations be combined in a new relation with added value?, links between relations, groups of relations</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Analysis</strong></td>
</tr>
</tbody>
</table>
A possible analysis of a design process is to compare the planned and executed design activities (visible in two columns) to see if everything that is planned, is executed already.

For the execution of a sub-task (during a design session), it can be very useful to show the current and the desired state in two separate screens. The desired state changes less than the current one.

− Overviews in which time is included
− See a number of important things at the same time
− See a number of versions at the same time
− See the design history
− See overview (in blocks which can be opened, with relations)

Print other things for different persons

It must be possible to structure the same data in different ways.

Possible check: a relation between two properties or factors on the same level of abstraction can have no ‘part of’ relation; in the current state, no desired properties can be entered, etc.

**User interface**

Limit the possibilities of the predefined values in the electronic forms, based on the position of properties or factors in the tree.

Include reflection in the user interface

Easy user interface

Add concrete questions in tree.

The list of perspectives will become too long after some time using the prototype.

Can choose between predefined values and can add new

**Links with other tools**

They also mentioned the difference between configuration and version management.

Perhaps, reflection can be coupled to a version management system: ask for information, change information, store changed information, and reflect.

They also mentioned the possibility to link actions to important decisions (including rationale and date of decision) (see design history systems).

When using the prototype in current practice, product and process data will be stored twice: in a domain-specific tool (Compiler, CAD, etc.) and in a project-management system and in ECHO. For software, the product and design process are already linked in a development environment (forces a certain process).

Tool as an extension on existing tools? (for example, on UniGraphics). ASML already works very structured.

On one database, different tools can be built with their own user interface. It is good to distinguish between the database from the specific tool ECHO. Users can build their own tool and user interface on the database.

**Questions**

Is a link between states and activities desired?

Also see reflections of others?

How can entering data and reflection be coupled?

Becomes a group tool (reviews) or individual (reflection on own design process)? Documentation for a designer himself or for other is fundamentally different (less argumentation and more detail in personal documentation).

**References**

− tool MAYA (Delft): relations, group things, overview (Nicole)
− tool Delphi

**Implementation improvements**

− When double click on property or factor in tree, the Detail DF window appears.
− Right mouse button: add, delete
− To fold out the tree: enter; to close tree: escape

**Comments of programmer:**

− a designer can choose in the menu what he likes to be sustained and what not
− when entering a relation, offer possibility to enter properties or factors first

5.2.2.5  Version 3

The junior designers judged the prototype as having some potential value. However, the tool does not yet have a useful ‘form’. They evaluated the prototype as follows.
At this moment, the current prototype is more a managing than a reflection tool. In design practice, the prototype would easily evolve to a management tool. The prototype mainly sustains administration of the design process (data processing and documenting). It offers mainly support to write down what a designer does instead of being a stimulus for future design activities. However, supporting reflection on the design process is related to management tools, which want to support controlling and monitoring the design process.

For the development of the tool, some important choices must be made.

− How to attain the goal of the tool, namely support a designer with reflection on the product being designed, the design process, and the design context, without developing a management tool?
− Will the prototype become a group (reviews) or individual (reflection on own design process) tool? Will it be possible to see reflections of other designers? This choice is important because documentation made by a designer for himself or for others is fundamentally different: less argumentation and more detail in personal documentation. The junior designers mentioned that the prototype could be interesting for bigger organisations in which many people are involved.
− How can administration of the design process and reflection be coupled? Is it necessary to couple these?

There was no consensus between the designers about several aspects of the prototype. Some designers mentioned that the tool makes it possible to get an overview, others described that the dimensions of a computer screen (too small) make it impossible to get a good overview. It was also said that, on the one hand, a good insight into the relations can be obtained with the prototype; on the other hand, designers mentioned the disadvantages that the prototype does not contain a specific structure for relations and does not give a good overview of underlying relations. The proportion between the period of using the tool in relation to the period of design was judged as reasonable and as too much.

The designers did agree on the following advantages and disadvantages. Advantages of the design tool are that

− the prototype aids not to forget important things,
− simplifies the administration,
− the tree is a useful structure,
− the predefined values are good examples of answers; the possibility is given to define new values yourself.

Disadvantages mentioned by the designers are that

− the design tool asks too much work,
− the user interface is not clear,
− the prototype is textual, whereas a designer works graphically.

Compared to the design method, the prototype is less imperative. However, the question was asked, is automatizing the design method a step forward? Computer support is not necessary for reflection. For some designers, the lack of overview makes the prototype less useful than the paper version. Compared to handwriting, the information is better readable on a computer, but there are limitations to the number of characteristics. Data can be edited more easily, but some designers judged navigating through the data as more difficult.

The designers suggested the following general improvements of the prototype.

− A possibility to change the template during the design process (only add and not delete items to keep the data-structure consistent!);
− Guide designers to come from vague relations to the type specified in the prototype, since a number of steps must be executed: make a textual description on paper, split the text in cause and reason, enter two properties and or factors in the tool, and finally make the relation;
− A possibility to see a number of versions of properties and factors at the same time and to add to the different versions the changes regarding the previous version and the reason of the change;
− A possibility to combine two relations in a new relation with added value, to make links between relations, and to group relations;
− A possible analysis of a design process is to compare the planned and executed design activities (visible in two columns) and to check if everything that is planned, is executed already;
− For the execution of a sub-task (during a design session), it can be very useful to show the current and the desired state in two separate screens that can be viewed at the same time;
− A possibility to include decisions, to link actions to important decisions, and to see the design history;
− A possibility to get an overview of the design situation and the design process, visualised by blocks which can be opened and by relations between these blocks;
− A more modular structure for the information;
− A different graphical representation for the structure based on the product being designed, the design process, and the design context;
A possibility to structure the same data in different ways;
A possibility to print an overview for each subject and to print other things for different persons;
Consistency checks carried through. Possible checks are: a relation between two properties or factors on the same level of abstraction can have no ‘part of’ relation; in the current state, no desired properties can be entered, etc.;
A link with existing tools and a link with text documents, drawings, and animations;
The difference between configuration and version management was mentioned. Perhaps, reflection can be coupled to a version management system: ask for information, change information, store changed information, and reflect;
When using the prototype in current design practice, product and process data will be stored twice: in a domain-specific tool (Compiler, CAD, etc.) and a project-management system and in ECHO. For software, the product and design process are already linked in a development environment (which forces a certain process). The tool can perhaps be made as an extension of existing tools (for example, on UniGraphics);
Different tools can be built on one database, each tool with its own user interface. It is good to distinguish the database from the specific tool ECHO. It can also be useful to make a form editor.
A user interface easy to use;
Reflection must be included in the user interface of ECHO;
More graphical visualisation (of relations);
A consistent terminology between the design method and the tool.

Some more implementation-oriented suggestions are the following.
Add concrete questions in the tree;
To fold out the tree: enter; to close the tree: escape;
A possibility to copy, paste, drag, and drop properties, factors, and relations (as functions of right mouse button);
When the user double clicks on a property or factor in the tree, the Detail DF window appears;
Limit the possibilities of the predefined values in the electronic forms, based on the position of the properties and factors in the tree;
The list of predefined values in the electronic forms will become too long after using the prototype for a longer time;
Implement the actual/obsolete-attribute with a radio button.

Comments of programmer:
- a designer can choose in the menu what he likes to be sustained and what not
- when entering a relation, offer possibility to enter properties or factors first

Comments
Tool is a side-product of the design method (become rich with the tool!).

Questions
Is a link between states and activities desired?
Tracking or also predict data?

References
- tool MAYA (Delft): relations, group things, overview (Nicole)
- tool Delphi
6 Results of the analysis and synthesis

The goal of this chapter is to offer a description of the feedback that has been received on each result of the Ph.D. project from the expert and junior designers. The results of the Ph.D. project can be found in [Reymen, 2001a]. The feedback given below is also partly integrated in the conclusions about the results of the research project (Chapter 6 in [Reymen, 2001a]).

6.1 Feedback on the design philosophy

In general, all experts recognised the concepts of the design philosophy and understood its terminology; the concepts and terminology seem to be domain independent. To improve my description of design processes, they suggested adding the concepts of risks (uncertainties) and of iterations. The concept of risks can be found in Section 3.3.2 of [Reymen, 2001a]; the concept of iterations is discussed in Section 3.5.1 of [Reymen, 2001a]. The experts stressed that changing desired properties during a design process is common practice. The architects also stressed the importance of the design context and the interaction of designers with the design context during a design process. The importance of changes and interactions is written down by Henk Döll [LeCuyer (ed.), 1999] as follows: “The problem is constantly revised, reshaped, and reframed through interaction with this complex entity called the client.”.

6.2 Feedback on the design frame

The relevance of the three dimensions of the design frame was judged as follows: Koster sees the dimensions as abstractions that can be used in a general language; such a language is necessary to understand designers from different disciplines. Abstractions, together with representations, are very important and their importance will increase in design practice when everything must be communicated faster and more efficiently. Brouwer says that, not only designers, but also the commissioners have to see the importance of dimensions. Already at the beginning of a design project, it is important to consider different levels, different aspects, and different processes in the product lifecycle. Commissioners must give designers time to do so.

The experts also asked questions to get a better understanding of the concepts of the design frame. These questions inspired me to improve the description of the design frame.

Specific comments I received on each of the dimensions are the following:

- Brouwer mentions that levels are very important: Architects have to look at both the overall structure and the details. Döll also says that levels are substantial in architecture. Architects must be trained to think on different levels of abstraction; for example, when an architect works on a high level of abstraction (part of a city), it is also important to consider in detail the functions or the compactness of the buildings.
- For Koster, the most important perspective is that of the customer; other viewpoints must be derived from the former. Brouwer supports the importance of the perspective dimension, calling it ‘the study of aspects’. A designer should not concentrate on one aspect in isolation; in a design, always multiple aspects are important.
- Koster mentions that paying attention to other processes than the design process is very important.

6.3 Feedback on the design method: expert designers

Table 6.1 shows different kinds of reflection and critical analyses already performed in the current design practice of the experts. A distinction is made with respect to different moments in time when the reflection is executed, with respect to reflection by an individual (I) and a group (G), with respect
to formalised (F) and non-formalised (NF) reflection, and with respect to the fact that results of the reflection are used for documentation (D) or not (ND). For the expert designers, the term ‘session’ refers to meetings (group sessions); I could distinguish the following kinds of sessions (meetings) in the design practice of the experts:

- progress (time and money) and contents (plan, techniques) meetings (in complex projects),
- regular and incidental meetings,
- internal (in company) and external (with customers, other stakeholders) meetings.

Before using the design method in practice, it must thus first be analysed how to combine my ideas of reflection and design sessions with the current kind of reflection and sessions used in practice.

Brouwer mentions that the need for reflection on design processes is high: Certain aspects (mainly the production methods and the market) are usually only too late in a design process taken into account. This results in many problems during the implementation process: 30 to 40% of the design has to be redone. The latter consumes a lot of time and money and results in a lot of misery.

Suggestions for the possible application of the design method in design practice are the following:

- Learning sessions must not be executed too often. Non-trivial analyses consume very much time; when these analyses are executed too often, it becomes a ritual, people avoid the problems, and do not learn anything. (Van der Sanden)
- Van der Sanden sees possibilities for a briefing and de-briefing about the design situation every week. He thinks that awareness of the product being designed, the design process, and the design context becomes routine when reflection on the design situation is performed too often.
- Koster calls reflection a retrospective moment. For him, retrospective moments can best be based on the planning of a project. During certain phases, reflection is not meaningful, because only less important decisions are taken.
- Both architects (Brouwer and Döll) suggest incorporating the design method in the qualitative procedures of an architect’s office; only then, architects are forced to work methodically (make documentation and check things). In a quality handbook made by Mecanoo, it is already described what must be done in each design phase. The handbook consists of checklists that describe all documents that are needed, the parties with which a discussion is necessary, and which calculations must be made. The role of the project leader is to check these lists. To make such a quality handbook, it is necessary to keep in mind that work should be structured but not too structured. The quality handbook must be used in a flexible way: Certain aspects are not always important in a specific phase in a specific project. The starting point is that you work in a professional organisation with high-qualified persons; these persons must be able to follow certain procedures without being controlled too strongly.

Because in my design method the length of a design session is flexible and checklists and forms can be made, among others, company specific, the design method can be applied as suggested by the expert designers.

<table>
<thead>
<tr>
<th>REFLECTION</th>
<th>MOMENT IN TIME</th>
<th>I/G</th>
<th>F/NF</th>
<th>D/ND</th>
</tr>
</thead>
<tbody>
<tr>
<td>Awareness of the mental state of the designer</td>
<td>Each hour</td>
<td>I</td>
<td>NF</td>
<td>ND</td>
</tr>
<tr>
<td>Thinking about the achievements and progress of the day (Note that people who do not do so, will likely not be triggered by a method to do so (Kruithof).)</td>
<td>Every evening</td>
<td>I</td>
<td>NF</td>
<td>ND</td>
</tr>
<tr>
<td>Thinking about what needs to be done the next day; make a to-do list (Van der Sanden, Döll)</td>
<td>Every evening</td>
<td>I</td>
<td>NF</td>
<td>ND</td>
</tr>
<tr>
<td>Status reports from employees working externally, required by a project leader</td>
<td>Every week</td>
<td>I</td>
<td>F</td>
<td>D</td>
</tr>
<tr>
<td>Evaluation of the satisfaction of a client, by employees working for that client</td>
<td>Regularly</td>
<td>I</td>
<td>F</td>
<td>D</td>
</tr>
<tr>
<td>Informal questions asked to employees working externally (Learned something interesting?)</td>
<td>Regularly</td>
<td>I</td>
<td>NF</td>
<td>ND</td>
</tr>
<tr>
<td>Reports for clients</td>
<td>Regularly</td>
<td>I</td>
<td>F</td>
<td>D</td>
</tr>
<tr>
<td>Status reports of regular meetings</td>
<td>Every two months</td>
<td>G</td>
<td>F</td>
<td>D</td>
</tr>
</tbody>
</table>
### 6.4 Feedback on the design method: junior designers

The general goal of the design method was clear to the junior designers. The example of the garden house was useful to offer more insight into this goal; however, an explanation based on a real case from design practice would have been more valuable. The junior designers judged the concepts of the design method as useful. The form and elaboration of the design method (at that moment), however, were seen as not yet good enough to be useful in design practice. It would also be difficult to sell the design method to management because no visible or measurable effect on throughput time could be shown; the designers would only use the design method when they could see the advantages. I believe that the form and elaboration of the current design method may be useful in practice. Despite the fact that I cannot yet show positive effect on throughput time or on the quality of the design, I believe that the method can increase the efficiency and effectiveness of the design process. I also believe that after using the design method during some design sessions, the designers (and their management) can see the benefits of structured reflection for improving design processes.

A negative aspect of the design method mentioned very often by the designers was that the design method was presented in a very general way and that it was not focussed to a specific discipline. Making the translation of the general terminology of the design method at that moment to the designer’s discipline-specific terminology was experienced as difficult. No domain-specific questions were included in the checklists. The design method also forced designers to write down very specific information and left them little freedom. A different structure for specific phases would be advantageous. The design method also required too much administration from the designers. The junior designers suggested that reflection might not necessary require the documentation of a lot of information; documenting has several negative aspects: The information written down is not necessarily only used by the designer whereas reflection is personal; there can be a problem of consistency and completeness; and it can be difficult to find back information. In the current version of the design method, the terminology of the design frame (which is too abstract for designers) is replaced by attributes (see Section 5.3.1 in [Reymen, 2001a]). The design method now suggests making (domain) specific forms and checklists for a specific application of the design method; the forms and checklists can be tailored to a specific user, company, or discipline, but also to specific phases in the design process. Defining sessions taking a long period of time can solve the problem of too much administration. Further research is necessary to find out what amount of information is necessary for reflection.

The designers mentioned that the amount of time spent on reflection during a design session depends on the product being designed, requirements from the market, and the throughput time. An optimal proportion between reflection and design felt to be about 10% for reflection and 90% for design. The design method can be used faster when the terminology is known better; some learning time is needed to get experienced with the design method and to use it efficiently. It was also said that reflection once during a design session (instead of at the beginning and end of a session) is enough; otherwise, it consumes too much time. Others said that once a day is enough. Because the length of design sessions is flexible, designers can plan their moments for reflection according to their preferences.

Almost all participants mentioned the same advantage of my design method, namely that it offers help to get an overview (of the design situation and of the design activities). Other characteristics of the design method mentioned by the designers are the following: The design method
- can help to increase awareness about the design situation, the steps taken, and the working method;
- asks relevant questions to think about;

| Reports (drawings, calculations, decisions) | At a milestone | G | F | D |
| Scenario-telling: telling stories about the consequences of certain decisions for the future. | Every three months | G | NF | ND |
| Evaluation | At the end of a project | G | F | D |

Table 6.1: Different kinds of reflection in (part of) current design practice.
- can help to identify problems that might otherwise have been forgotten;
- supports learning from shortcomings;
- can help to work more in a focussed way;
- can help to bring order in a chaotic design process;
- offers opportunities to define and improve the design process;
- is directed towards a continuous improvement of the design quality and a comparison with other stadia of the process; the comparison of the present state with the past and the future is important;
- can help to make good documentation of the project state;
- offers help to describe the design process; the availability of this information later on in the design process is useful;
- can give more confidence in the completeness of the information.

Determining the possible value sets for the three dimensions once at the beginning of a project (with the current FORM Design Frame) was regarded as very useful. Also determining terminology and definitions can be very useful; it must then also be possible to structure these definitions in different ways during the course of a design process. Documenting at the end of a session what has been done and which problem has been solved was also seen as very useful.

The designers suggested the following improvements:
- give an explanation based on an example in a specific discipline;
- make translations of the terminology to specific disciplines (domain-specific forms and checklists);
- make the checklists and forms adaptable in time and adaptable to a specific designer;
- make the design method more compact (decrease the number of forms in order to decrease administration);
- test the method in a design process taking more than one month.

As mentioned before, the design method now suggests making (domain) specific forms and checklists for a specific application of the design method. Further research is still necessary to make the design method more compact and to test the design method for a longer period of time.

6.5 Feedback on the prototype software tool: expert designers

Suggestions from the expert designers to extend the prototype for use in practice are the following:
- The tool can be extended for supporting learning. Van der Sanden mentions that learning from earlier experiences is not yet supported in practice: Existing support concentrates on development (how to design), modelling (how to represent reality), and management (how to control a process). Brouwer says that the biggest problem of a tool supporting learning and reflection is how to enforce people to think about certain aspects and not only mention the aspects.
- The tool can be extended for process support. Döll qualifies process support as highly useful. For architecture, a link can be made with a quality handbook. The idea of a checklist can be elaborated; with software, a checklist can easily be made specific for a project (copy and paste of a general checklist). The checklist can show what must be done.
- The tool can be extended for concurrent engineering. Koster sees possibilities for all parties to retrieve information on the project from the database of the tool. He adds that the tool must be tested in complex projects involving multiple disciplines.
- The tool can be extended for documentation and control. Van der Sanden mentions possible things to document: important decisions, ideas, user opinions, planned actions, risks (can be part of a checklist), and links to data of the product being designed. Possible things to control with the tool are checking the factors influencing a goal and checking if no things that are asked are forgotten. He suggests starting with unstructured data in the tool; when the amount of data increases, some kind of structure can be added. He also mentions that a user must make himself familiar with the tool by means of training; once familiar, the user can give input very fast and the ideas of the user can be checked very fast. A user also needs a training to choose good terminology. Döll, however,
mentions that during a design process, millions of things are important. Decisions cannot all be described and underpinned; many decisions are taken implicitly, only a few are taken explicitly. For Döll, an important requirement for the use of the tool is that information can be entered very fast. Kruthof says that designers will not be motivated to use this kind of tool in practice when it is enforced. Technicians like to make their own tool and they already think in an abstract way. The most important links between facts are already in their heads. In his perception, just entering data in a tool offers a designer not much added value; there is also a natural resistance against entering a lot of data. Only when a designer has experienced certain problems, such a tool will be appreciated; a designers sees the necessity to document relations when he realises in a practical situation that he forgot important relations.

The designers made these suggestions based on the current prototype, which only supports the description and analysis of design situations and which is not yet a tool supporting a reflection process. My suggestion is to extend and improve the prototype for reflection (and learning), as described in [Reymen et al., 2001]. Some kind of process support can be made part of the support for reflection. The suggestions about concurrent engineering and documentation and control seem useful to me and can also be taken into account when developing a new version of the prototype.

6.6 Feedback on the prototype software tool: junior designers

Implementation-oriented suggestions to improve the prototype, given by the junior designers, are described in [Reymen et al., 2001]. The junior designers judged the prototype as having potential value; however, the tool does not yet have a useful form. They mention that for the further development of the tool, the following important questions must be answered:

− How can the goal of the tool, namely support reflection on a design process, be reached without developing a management tool (a management tool aims to control and monitor the design process)?
− Will the tool become a group (reviews) or individual (reflection on own design process) tool? Will it be possible to see reflections of other designers? The answers are important because documentation made by a designer for himself and documentation made for others are fundamentally different (there is less argumentation and more detail in personal documentation).
− Is it necessary to couple administration of the design process and reflection?
− Is automating the design method a step forward? Computer support is not necessary for reflection. Answers to these questions are (partly) given in Section B.9 in [Reymen, 2001a], which discusses possible improvements and extensions of the prototype or in [Reymen et al., 2001].

About several aspects of the current prototype, there was no consensus between the designers. Some designers mention that the tool makes it possible to get an overview, others describe that the dimensions of a computer screen are too small to make it possible to get a good overview. It was also said that, on the one hand, a good insight into the relations could be obtained with the prototype, whereas on the other hand, designers mention that the prototype does not contain a specific structure for relations and does not give a good overview of relations. The proportion between the time spent using the tool in relation to the time spent designing was judged both as reasonable and as too much.

The designers did agree on the following advantages and disadvantages. Advantages of the design tool are that the prototype helps not to overlook important things and it simplifies administration; furthermore, the tree structure is useful and also the predefined values are useful. Disadvantages mentioned by the designers are that the design tool asks too much work, the user interface is not clear, and the prototype is textual, whereas a designer prefers to work graphically.

Compared to the design method, the prototype is more flexible. For some designers, the lack of overview makes the prototype less useful than the paper version (the design method). Compared to handwriting, the information is better readable on a computer, but there are limitations to the number of characters. Data can be edited more easily, but some designers judged navigating through the data as more difficult.
The designers suggested the following extensions and improvements:

− an easy-to-use user interface (including more graphical visualisation (of relations) and functionality for reflection);
− a possibility to change the template during a design process;
− import/export facilities for text documents, drawings, and animations;
− import/export facilities for existing tools;
− when using the prototype in current design practice, product and process data will be stored at least twice: in a domain-specific tool (compiler, CAD tool, etc.) and/or a project-management system and in the database of the prototype: It is desirable to separate the database from the prototype, thus allowing a common database for different tools.
7 Conclusions

This report offers information about the performed empirical study at the end of my research project and about its results; it includes additional information that has not been written down in the Ph.D. thesis [Reymen, 2001a]. Chapters 2, 3, and 4 of this report give attention to the approach to the feedback, including the detailed protocol to get feedback from expert and junior designers; Chapters 5 and 6 discuss the analysis and synthesis of the feedback and the results of this processing process. Some final conclusions about the approach to and the results of the empirical study are the following. First, the goal of the empirical study I performed at the end of my research project, namely getting an impression of the generality of my results and getting feedback on the relevance and usefulness of my results for design practice, has been met. Second, the empirical research was not called ‘test’, but ‘confrontation with design practice’, because the results have not been fully tested; for example, the concept of design sessions could not be fully tested, because only one day has been planned (the planned day included only two design sessions). For a real test, the design method (and prototype software tool) should be used during, at least, two weeks. Although limited, the feedback on my results learned me much about these results.
References


SAI Reports

ISSN 1570-0143

In this series appeared:

Isabelle M.M.J. Reymen

2001/2 Improving Design Processes through Structured Reflection: A Prototype Software Tool.
Isabelle M.M.J. Reymen, Elisabeth Melby

2001/3 Improving Design Processes through Structured Reflection: Case Studies.
Isabelle M.M.J. Reymen

Isabelle M.M.J. Reymen