Comparing paradigms for describing design activity

Kees Dorst and Judith Dijkhuis, Faculty of Industrial Design Engineering, Delft University of Technology, Jaffalaan 9, 2628BX Delft, The Netherlands

In this study the two main paradigms for looking at the design activity are compared in terms of their ability to describe the industrtial design process. Special interest is paid to how close these descriptions are to capturing the design activity as experienced by the designers themselves.

Keywords: protocol analysis, design activity, problem solving, reflection-in-action

This collection of papers will help to show that there are many ways of describing design processes. Each researcher will have attacked the design process in his/her own way, based on a unique choice of assumptions and goals. In this paper, two basic and fundamentally different ways of approaching the design process will be discussed, and evaluated on their descriptive value.

1 Two paradigms for describing design activity

Over the years, many systems for describing design processes have been developed. The 'first generation' methods of design methodology in the early 1960s were heavily influenced by the theories of technical systems. The positivist background of these theories made for design being seen as a rational (or rationalizable) process. Criticism of these models raised interest in the fundamentals of design theory, the logical form and status of design. It also fostered a need for more detailed descriptions of the design activity, leading to more attention for designers and design problems, rather than just for the design process.

Problem solving theories introduced by Simon[1] provided a framework for this extension in the scope of design studies by allowing the study of designers and design problems within the paradigm of technical rationality. He also provided a sound, rigorous basis for much of the existing

1 **Simon, H A** *Sciences of the artificial* MIT Press, Cambridge, MA (1992)

BUTTERWORTH HEINEMANN 0142-694X/95 $10.00 *Design Studies* **16** (1995) 261–274 0142-694X(94)00012-3
Elsevier Science Ltd Printed in Great Britain

knowledge in design methodology. This paradigm, in which design is seen as a rational problem solving process, has been the dominant influence shaping prescriptive and descriptive design methodology ever since. Most of the work done in design methodology today still follows the assumptions, view of science and goals of this school of thought (see Section 1.2). A radically different paradigm was only proposed some 15 years later, by Schön[2], describing design as a process of reflection-in-action. This constructionist theory can be seen as a reaction to the problem solving approach, specifically made to address some of the blind spots and shortcomings Schön perceived in mainstream methodology (see Section 1.3).

The two paradigms for design methodology represent two fundamentally different ways of looking at the world, positivism and constructionism. These two ways have been with us literally since Plato disagreed with Aristotle. We do not aim to solve that disagreement in this paper, but we do hope to shed some light on the properties and limitations of these two modes of looking for the study of design.

1.1 Design as a rational problem solving process

Seeing design as a rational problem solving process means staying within the logic-positivistic framework of science, taking 'classical sciences' like physics as the model for a science of design. There is much stress on the rigour of the analysis of design processes, 'objective' observation and direct generalizability of the findings. Logical analysis and contemplation of design are the main ways of producing knowledge about the design process. Simon quotes optimization theory as a prime example of what he believes a science of design could and should be[1].

The problem solving approach means looking at design as a search process, in which the scope of the steps taken towards a solution is limited by the information processing capacity of the acting subject. The problem definition is supposed to be stable, and defines the 'solution space' that has to be surveyed. The view of design as a rational problem solving process has helped, giving a much-needed stable basis to design methodology, and has informed much of our knowledge about design today.

1.2 Design as a process of reflection-in-action

In *The reflective practitioner* Schön has developed what he calls a 'primer' for a 'new theory of design'. He argues that the prevailing positivist paradigm is hampering the training of practitioners in the professions. He sees the training programmes as being defined in terms of generalities about the design problems and design processes, without any attention to

2 **Schön, D A** *The reflective practitioner* Harper Collins, USA (1983)

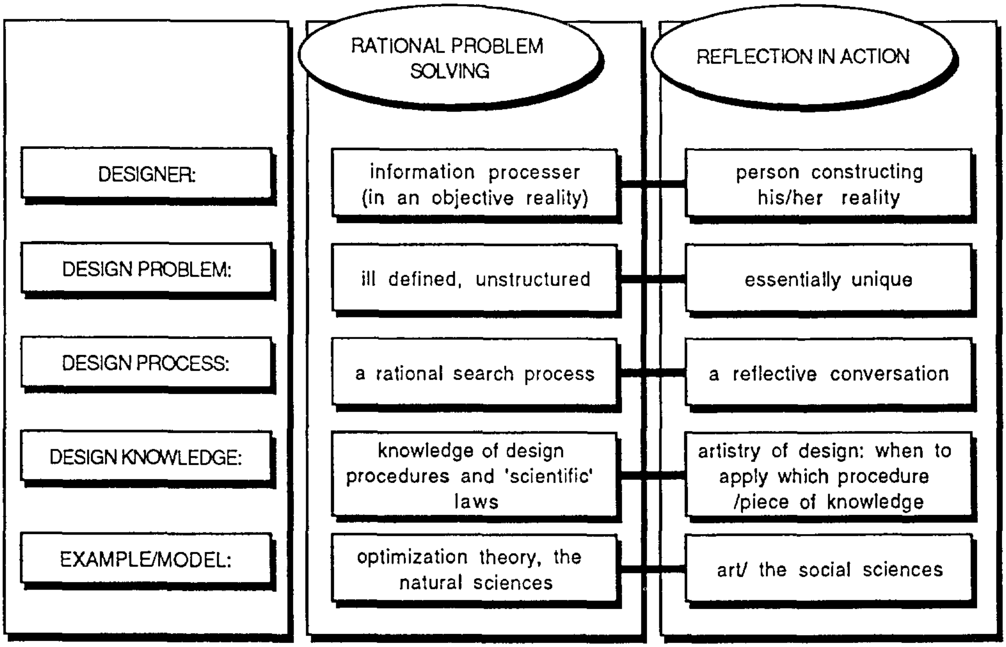

Figure 1 The rational problem solving paradigm and the reflection-in-action paradigms summarized

the crucial and difficult problems of the linking of these two in a concrete instance. Any design problem is unique, a 'universe of one', and a core skill of designers lies in determining how every single problem should be tackled. This has always been left to the 'professional knowledge' of experienced designers, and has not been considered describable or generalizable in any meaningful way. But Schön calls this the essence, 'the artistry' of design practice. Thus he finds it unacceptable that these problems cannot be described in the prevalent analytical framework, and that their solving therefore cannot really be taught in the professional schools.

To describe the tackling of fundamentally unique problems, Schön proposes an alternative epistemology of practice, based on a constructionist view of human perception- and thought processes. He sees design as a 'reflective conversation with the situation'. Problems are actively set or 'framed' by designers, who take action (make 'moves') improving the (perceived) current situation.

A summary of the two paradigms is given in Figure 1.

2 Criterion: describing the design situation

The aim of this paper is to compare the different paradigms for describing design processes on the closeness of their descriptions to the design activity. 'Closeness' will now be defined as the measure in which these methods capture design in the way designers themselves *experience* it. Design is not just a process or a profession, it is *experienced as a situation* that a designer finds him/herself in.

2.1 The design situation

Until now design methodology has failed to systematically take into account this situation aspect of design. But if the academic field of design methodology wants to influence design practice and education, it should be sure to address the problems designers have, and do that in a way that designers recognize (experience them). A more fundamental reason for dwelling on the designer's experience of design situations is that the multistep process of designing is 'controlled' by the designer's decisions. These decisions are based on the perceptions of the designer at work in his/her design situation. This makes the understanding of (at least this perceptual aspect of) the design experience a prerequisite for any real understanding the design activity itself.

But what kinds of things do designers experience whilst being in the design situation. This has for instance been touched upon by Winograd and Flores[3]. A situation is defined by the subjects' perception of the current state, goals and possibilities for action, and his/her way of dealing with 'thrownness'.

(Winograd and Flores use a situation comparable to design (chairing a meeting) as an illustration of Heideggers' notion of 'thrownness'. When designing, you are in a situation that

1) You cannot avoid acting
2) You cannot step back and reflect on your actions
3) The effects of action cannot be predicted
4) You do not have a stable representation of the situation
5) Every representation is an interpretation
6) You cannot handle facts neutrally; you are creating the situation you are in.

The philosophical theory behind this approach to reality is phenomenology, created by Husserl, and later extended by Heidegger and Merleau Ponty[4,5]).

3 **Winograd, T and Flores, F** 'Understanding and being' in, *Understanding computers and cognition: a new foundation for design* Ablex Publishing, Norwood, NJ (1990)
4 **Heidegger, M** *Phenomonology of perception* Routledge, London (1992)
5 **Merleau-Ponty, M** *Phenomonology of perception*, Routledge, London (1992)

As a designer, you are in a situation that you are continually faced with the very concrete challenge of your perceived design problem, and you have to decide on the kind and content of the action to take in this situation. 'What does this situation mean'? and 'What action can/should I take in this situation?' are eternally recurring questions. In most cases, considerations linked to the content of the design situation (the perceived design problem, the designer's goals and the perceived possibilities for the next step) will determine the 'kind of action' (process-component).

It should be noted that designers also make process-driven decisions, in particular when they are making a plan or checking their progress. But this requires them to 'step out of their design situation'. These 'jumps' into a wholly different way of thinking can easily be seen in any protocol of a designer at work. The conclusion must be that these process-driven decisions, the object of much of current design methodology, are not really part of the core design activity itself.

2.2 *The limits of design methodology*

In studying design as a process, one is looking at the process-component of largely content-based decisions. This severely limits the power of a process-oriented methodology to understand what is going on in the design activity, and to help designers who are trying to work their way through the design situation toward a solution. Because of this process-focus very little knowledge and hardly any theory has been built up about the kinds and content of design problems, or the kinds of goals designers have (such a coherence and integration). We are strongly convinced that in order to obtain to a deeper understanding of the design activity, design methodology should now start to address at least some more aspects of the design situation.

2.3 *The layout of this study*

This paper will focus on finding out how much we know and could come to know about the design situation, using the two main paradigms of design methodology as the best 'tools' we have. This will be done by performing a protocol study, and trying two different data processing systems that correspond with (are distilled from) the two paradigms that lie at the basis of design methods. The performance of these data processing systems in capturing the design situation will be seen as a measure for the 'descriptive value' of the paradigms themselves. Attention will focus on the ability of both description methods to preserve the link process-content in design decisions, and capture the perception of the design.

It should be noted that this paper is a rather informal presentation of a larger study, in which the two paradigms were compared much more thoroughly. The notion and mechanism of 'integration' was defined in both paradigms, and protocol data was processed with the two data processing systems. The space here does not allow the full treatment of that approach, and in the end we decided to omit it altogether. But some of the conclusions at the end of this paper have been drawn on the basis of this much larger and more thorough analysis. That analysis will be reported fully in the thesis by the first author, to be published later this year.

3 Applying the two paradigms of design methodology

The encoding systems based on the two paradigms are introduced, demonstrated and discussed in Sections 3 and 4, respectively. Here we will draw some more general, theoretical conclusions about their behaviour. Overall conclusions will be drawn in Section 5.

3.1 Describing the design activity as a process of rational problem solving

There is an uneasy relation to the paradigm of rational problem solving with empirical research. Logical reflection has always been the main productive method for researchers working within this paradigm. Protocol studies are seen as worthwhile, although the value of the results is constantly under fire. Case studies are definitely seen as irrelevant, because they do not lead directly to generalizable knowledge of the design process. But there have been a large number of empirical studies that clearly operate within the paradigm as outlined above. One of the empirical studies that is most interesting to us, is reported by McGinnis and Ullman[6]. It is a detailed study that gets very close to a description of the content as well as the process of design decisions while staying within the rational problem solving paradigm. This analysis has been extended and repeated here.

Every 15 seconds of the design process was scored with a data processing system, containing five main categories:

1) Acts – what does the designer do: write, think, sketch, take a break etc . . .
2) Goals – with which goal does the designer perform this action: determining the problem, making a performance specification, building the concept, plan etc . . .
3) Contexts – from which perspective does the designer look at the problem: the user, the bicycle company . . .

6 McGinnis, B D and Ullman, D G The evolution of commitments in the design of a component, *Journal of Mechanical Design*, Vol 144, (1992), 1–7

4) Topics – which topic is the designer dealing with: the bike, company policy, the maximum size of the product, materials etc . . .
5) Auxiliary topics – is the designer working in comparison with other products, referring to earlier projects, or in any other way reflecting on his/her own way of working.

A score for a 15 s stretch of a design process then looks like: 03 02 05 35 00. This translates back into: the designer is writing (03) the performance specification (02), looking from the viewpoint of the users (05) at the location of the backpack (35) (without reflection on design or comparing to other products (00)).

It should be noted that there is a direct correspondence to Simon's problem solving theories[7]. The 'knowledge state' of the designer can be deduced from combining the 'context' and 'topic' categories. A 'problem-behaviour graph' could be constructed by combining these categories, and mapping them cumulatively.

3.2 *An overview of the protocol*

This overview of the individual protocol takes the form of four graphs, reflecting the four main categories of the encoding system. Two of these have been printed here as examples (see Figures 2 and 3). For these categories, the scores used for encoding are listed, followed by the corresponding graph of the workshop protocol of the individual designer.

3.3 *Discussion*

The space allotted to us in these proceedings does not allow a complete discussion of the results. A few remarks will have to give an impression of what struck us most in this analysis.

The encoding

- The 15 s interval time for scoring the protocols was just about right. (see also the paper by Akin and Lin elsewhere in this issue). The designers seldom change subject or approach twice in such an interval.
- The subjects that the designer is dealing with, 'topics' in this encoding system, were surprisingly hard to score. Although the encoding system does provide a large number (over 60) of a priori categories to make scoring easier, these were by no means enough to capture the vagueness and subtleties of concept manipulation. Varying degrees of interpretation were required.

7 Newell, A and Simon, H A *Human problem solving* Prentice-Hall, Englewood Cliffs, N J (1972)

Category 3: Context		
None		00
Neutral		01
By stakeholders	– The company Hi Adventure	02
	– The company Batavus	03
	– The designer	05
	– The users	06
By aspects	– Ergonomical	07
	– Technical	08
	– Form	09
	– Business	10

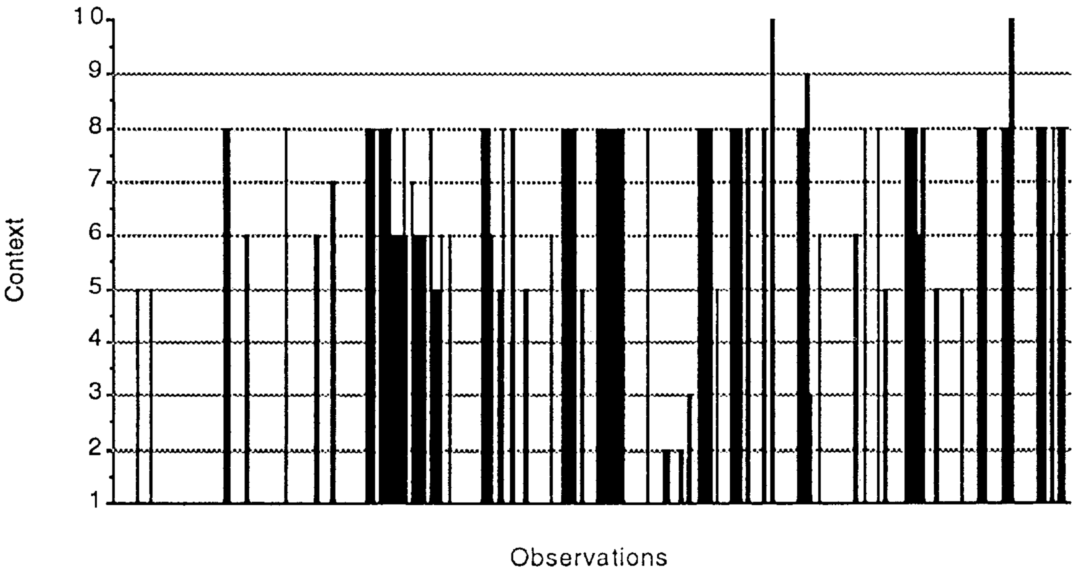

Figure 2

Category 4: Topic		
None		00
The subject:	Brief, the problem as such	01
The project	Hi Adventure: – Policy	10
	– Resources (time and tools)	11
	– Position (role in the project)	12
	Batavus: – Policy	13
	– Resources (time and tools)	14
	– Position (role in the project)	15
	Users: – Policy	16
	– Resources	17
	– Position (role in the project)	18
	The designer: – Goals (ideals)	20
	– Resources (planning)	21
	– Position (role in the project)	22
The environment phyical environment of the product		23
	The bicycle – all	24
	– the Buster	25
	The backpack	26
	User behaviour	27
	Competition/patents	28
	Norms/rules/laws	29

The product		
In terms of basic problems/solutions	– general principle/layout	30
	– use –put on/– put of backpack	31
	– „ fastening device	32
	– technical – put on/– of backpack	33
	– „ fastening device	34
	– location of backpack	35
	– materials	36
	– production method	37
	– costs and price	38
	– stability bicycle	39
	– quick joining/accessory	40
	– fit to most mountain bikes	41
	– wobbling of content	42
	– looks	43
	– sizes	44
	– stiffness	45
	– safety	46
In terms of physical parts:	– Fastening device	50
	– Joining mechanism backpack	51
	– Joining mechanism interface	52
	– stack-away mechanism	53
Possible physical parts of the system:		
	– Pins	54
	– Snaps	55
	– Braze-ons	56
	– Tubes	57
	– Crank	58
	– Fenders	59
	– Brackets	60
	– Mounting point	61
	– Lugnut	62

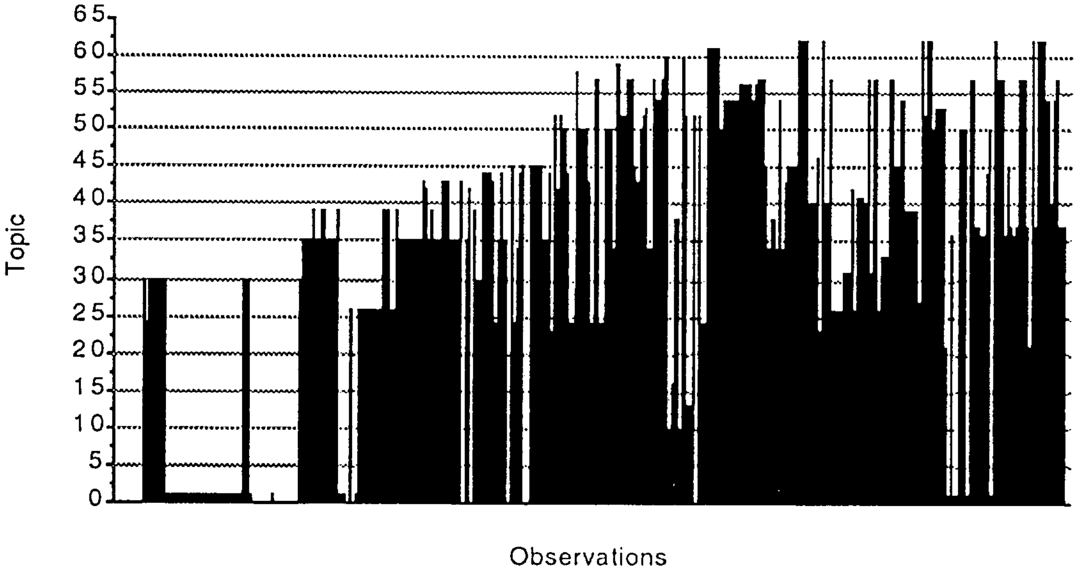

Figure 3

The encoding system

- The encoding system was based on a simple classical analysis-model, which means that observations are classed in a priori categories and that connections between subsequent observations are severed. This makes the encoded data hard to 'read'.
- In order to find out what is happening, one really has to refer to the written-out text of the protocol. Apparently, some vital information is lost in the severing of the links between observations, and in the use of the a priori categories. Just reading the encoded data gives you no idea what the concept looks like.
- The written-out protocols give the impression of the designer being pretty consistent in his concept-building process, but the graphs show no pattern at all in the concept-building stage. This must mean that the encoding demolishes or at least fails to capture the pattern that is there.
- Statistical analysis of these nominal data can give some information on how often this or that category has popped up. But this analysis only allows us to compare stretches of time, and tells us nothing of the possible importance of a category for the design activity.
- The persistent recurrence of a certain category (in this case, topics no. 35 and 39, 'location' and 'stability', for instance) can give some inkling of its possible importance.
- The graphs could lead to remarks on the time-scale of some of the design activities: Many people comment that the designer starts drawing much later than they expected (but the one-hour mark is pretty consistent with our own earlier research). The lack of basic design theory precludes any firm conclusions.
- However, the alternation between the different activities, contexts, and topics does provide information about the general nature of design processes.

3.4 Conclusions on the descriptive value of seeing design as a process of rational problem solving

- The 'topics' categories, combined with the acts and goals, gives some idea of the reasons for the different steps and the eventual course of the design process. But this way of looking at the design process has no way of dealing with the logical links of the one to the other. Links can be reconstructed, but textual analysis (concentrated on the content of the design problem, and consequently outside this paradigm) remains necessary to forge them solidly.
- Patterns can be found in the scored protocol data, echoing strategies

or heuristics in the design activity. These patterns can be most clearly seen in the information- and embodiment phases, when you could expect more routine-like behaviour. The conceptual phase shows an erratic jumping between activities, with hardly any pattern at all.

- The paradigm of rational problem solving does not provide a basis for the study of design problems and their structures, and is very much focused on the process-component of design decisions. That limits the understanding one can obtain from analyses like these of the design situation. The lack of theory on design problems makes this way of looking at the protocols little more than a bookkeeping of the design process.
- The rational problem solving paradigm does not provide us with detailed theory on what would be a 'good' or 'healthy' design process. Some general principles like concentric development, and working from the abstract to the concrete can be found in every protocol hitherto collected by the authors; they cannot explain the differences in quality of the end result.
- This kind of data processing system can be very valuable in comparing design processes. This is the way it was used in the thesis mentioned above. There the results of this analysis are also linked to the quality of the end result, which gives a refreshing insight into what could be good and bad in design processes. Overviews like these can be instrumental in the formulation of more detailed hypotheses on the process-component of the design activity.

4 Describing the design activity as a process of reflection-in-action

Schön's well-written description of his architectural protocol sparks immediate, intuitive recognition by designers. It inherently combines the content- and process-component of the designer's actions. The essence of Schön's theory is that designers are active in structuring the problem, and that they do not evaluate concepts, but that they evaluate their own actions in structuring and solving the problem. The unit of 'doing design' is not a design concept, but an action.

Designers work by framing a problem in a certain way, making moves towards a solution and evaluate these moves on the criteria of

- Coherence (am I following a line of reasoning)
- Accordance with the specifications (am I on the right track)
- The problem-solving value ('have I made things worse'?)

The frames are based on an underlying background theory, corresponding with the personal view of the designer on design problems and his/her personal goals.

4.1 An example: the first half hour of the protocol

The first column gives the time in minutes, the designer is quoted in the second. The third column gives the kind of statement

- MV is a move
- FR is a frame
- BTH is 'underlying background theory'

('Blackburn' refers to Blackburn Inc., a large bike-accessories manufacturer that was called by the subject when he was 24 min into the design process.)

005	there's no use starting from scratch if you can start at square two	BTH
006	stability's an issue	FR
007	doesn't directly take advantage of the frame	MV
	(efficiency in construction)	BTH
010	Centre of gravity is very high	FR
010	you want to keep that as low as possible	MV
012	don't try and reinvent the state of the art	BTH
014	stability (connected to Blackburn)	FR
019	don't redesign things	BTH
023	. . . wanted to know whats the trade of between carrying panniers on the front versus the rear	FR
025	Centre of gravity is very high (question to Blackburn)	FR
025	did it in the front (question to Blackburn)	MV
025	not much space between the frame (question to Blackburn)	MV
026	pack on one side (question to Blackburn)	MV
028	push it further back (question to Blackburn)	MV

We can summarize further by only taking into account the 'successful' moves and frames (the ones that the designer stayed with). This gives a clear picture of the what, how and why of the design concept.

The design problem was framed as a stability problem.

- This reigns the positioning of the backpack
- And generally the technical context for the concept design (designed for maximum stiffness)

The most successful moves were:

- To position the backpack as low as possible lying above the rear wheel of the bike
- To adopt a triangular structure for the product

The background theories informing these moves and frames were:

- The efficiency of a process: don't reinvent the state-of-the-art
- The efficiency of a construction: triangular supports give the most stability for the least material

4.2 *Discussion*

The encoding

- This data processing system is reasonably easy to score. Most mistakes come from a confusion between frames and moves; better definitions could help the encoder getting his head straight

The encoding system

- This way of looking at the protocols is very much content-focused; something of the link process-content is preserved, but the process is not very well described. The links between consecutive statements are preserved. But a study of those links from these data still requires a lot of reconstruction and interpretation by the researcher.
- This description of the design process is staunchly problem-dependent. Research along these lines would result in studies that are very hard to compare, and thus hard to draw general conclusions from, case-studies, in fact.
- The formation of the concept can be followed very closely by looking along the lines of this paradigm. Information- and embodiment phases are only reported very sketchily, because the more or less routine sequence of moves in these phases requires only a few decisions to get started, and is only evaluated at the very end.
- The consistency of the design activity is much clearer in this description than in the other one. The frames provide the glue that tie the subsequent design statements together.

4.3 *Conclusions on the descriptive value of seeing design as a process of reflection-in-action*

- The link this paradigm provides (conserves) between design process and the content of the design problem is most valuable. But the treatment of design as a reflective conversation lacks the clarity and rigour achieved by the rational problem solving paradigm.

- This paradigm takes us closer to describing design-as-experienced than looking at design as a rational problem process does. The link process-content in design decisions is preserved, and so is the perception of the design problem.
- The weakness of the underlying theory makes it very hard to draw any general conclusions from this description of design. (e.g. because there is no theory on the structure of design problems, there is no basis for judging the appropriateness of a certain frame). This limits the usefulness of this theory of design as reflection-in-action to providing a very structured way of making case studies (for the time being at least).

5 *Conclusions*

Describing design as a rational problem solving process is particularly apt in situations where the problem is fairly clear-cut, and the designer has strategies that he/she can follow while solving them (as was the case in the information and embodiment phases of this workshop protocol). Describing design as a process of reflection-in-action works particularly well in the conceptual stage of the design process, where the designer has no standard strategies to follow and is proposing and trying out problem/solution structures.

Seeing design as reflection-in-action manages to describe the design activity without totally severing the close link between the content and process components of design decisions. Taking the action (move) as the 'unit for studying design' also gets us much closer to the activity of design as experienced by designers. This would put a very extended and systematized version of Schön's theory in a very good position for possible application in design practice and education. The theoretical base of this theory should be developed further, though, (e.g. building a taxonomy of design problems, and of frames) so that more rigorous and generalizable conclusions can be drawn from this. There is no theoretical reason why this could not be done. (and it has to some extent already been done by some of the expert-system builders[8]).

8 **Tzonis, A** 'Huts, ships and bottleracks: design by analogy for architects and/or machines' in: **N Cross, K Dorst and N Roozenburg (eds)**, *Research in design thinking* Delft University Press, Delft, The Netherlands (1992)