The reflective practice of design teams

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The aim of our studies is to develop tools and guidelines to improve team design practice. In order to improve team designing, we have to understand it, in order to understand we must be able to analyze and describe it. To describe the nature of team designing, we developed a new description method, based on Schön's theory of reflective practice. This method was tested by applying it in the description of the activities of two design teams. The description method proves to be very useful, in that it allows a concise description of a design project in which the elements vital to the understanding of the design progress are conserved. Comparing the obtained descriptions of these two teams designing reveals different patterns of behaviour. These patterns of behaviour arouse an interest in a more detailed and in-depth analysis of team design behaviour.

Keywords: design activity, teamwork, reflection-in-action, protocol analysis, research method

For team designing to be effective we rely on team members to support each other in answering questions that arise and in picking up lines of thought from each other to build on. This should give an added value compared to individual designing, where the designer creates his/her own private understanding of the design problem and the design solution. But by introducing several designers we also introduce the difficulties of team designing. These lie in synchronising the thoughts and activities of the team members. Judging from team observations this can cause serious problems for team members in interactions and conversations[1] and lead to misunderstanding and uncoordinated actions.

In this explorative study, we attempt to describe team designing in a manner that provides a survey of the teams' activities and that can be a starting point for analyzing team design behaviour. In this we follow Mazijoglou and Scrivener arguing that "... rather than being confirmed by data gather-

1 **Valkenburg, A C** 'Shared understanding as a condition for team design' *The Journal of Automation in Construction* Vol 7 Nos 2–3 (1998) pp 111–121

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ing—theories, methods and hypotheses..[can].. emerge from the data gathering process"[2].

The aim of our study is to provide team members and team leaders with tools and guidelines to improve their practice. Therefore we need to gain more insight in the nature of team designing. In order to improve team designing, we have to understand it, in order to understand we must be able to describe it. We need to describe and analyze teams working on design projects, to see where and why problems occur.

As an exploration one would like to observe design teams working on a design task, preferably in a real-life situation, and constructing a rich description of what the team is doing. The problem that has to be tackled in the making of such a description is that little of the research methods currently used in design methodology is suited for our purposes. The complexity of design has always made it difficult to study real life design activity, and none of the existing research methods to observe and describe designing provides us with data that is rich enough, in that it spans both the design process and relevant aspects of the design context.

Consequently, we had to develop our own description method. We built up a rich description method for team designing, using Donald Schön's theory of reflective practice[3–5] as a starting point. Schön has constructed a theory in which the role of the designers, the design task and the design process are integrated (see section 1). Schön's theory has already proved itself as a useful approach to describing individual design activities[6], but its properties in describing team designing have never been explored.

In this study we will investigate the suitability of the 'mechanism of reflective practice' for describing team designing. In section 1 we introduce Schön's theory of reflective practice. In section 2 we explain the data and design task of the observed teams. In section 3 we describe the results; the design project of the observed teams in terms of Schön's reflective practice. In section 4 we discuss the observed patterns of behaviour. In section 5 conclusions are drawn, and a basis is created for the further study of team designing.

1 Schön's paradigm of reflective practice

In his work Schön criticises technical rationality, the paradigm that is the basis of mainstream design methodology, arguing that design methodologists that work within this paradigm restrict themselves to terms of generalities about design processes. In Schön's opinion, too little attention is paid to the structure of design tasks and the crucial problem of linking

2 Mazijoglou, M and Scrivener, S A R 'The rich picture of design activity' *The Journal of Automation in Construction* Vol 7 Nos 2–3 (1998) 157–175

3 Schön, D A *The reflective practitioner* Basic Books, New York (1983)

4 Schön, D A 'Problems, frames and perspectives on designing' *Design Studies* Vol 9 No 3 (1984) pp 132–136

5 Schön, D A *Educating the reflective practitioner* Basic Books, New York (1987)

6 Dorst, K *Describing design—a comparison of paradigms* PhD Thesis Delft University of Technology (1997)

process and task in a concrete design situation. To him every design task is unique, a 'universe of one'. Therefore, one of the basic problems for designers is to determine how such a single unique task should be approached. This problem has always been relegated to the 'professional knowledge' of experienced designers, and was not considered describable or generalisable in any meaningful way. However, this does not satisfy Schön; he calls this tackling of unique design tasks the essence, the artistry of design practice. He finds fault with the prevalent analytical framework for failing to describe these activities, and regrets that the solving of unique design problems therefore cannot be taught in the professional schools.

To describe the undertaking of fundamentally unique tasks, Schön proposes an alternative view of design practice, based on the idea that "a kind of knowing is inherent in intelligent action"[3] (p. 50). This 'action-oriented', often implicit knowledge cannot be described within the prevalent methodological paradigm of technical rationality[7]. But Schön insists that this kind of knowledge is vital for action-oriented professions like design. He does recognise, however, that this implicit 'knowing-in-action' is difficult to describe and convey to students. What can be thought about and taught is the explicit reflection that guides the development of one's knowing-in-action habits. This he calls reflection-in-action.

Schön's theory is based on a constructionist view of human perception and thought processes: through the execution of 'move-testing experiments' (involving action and reflection), a designer is actively constructing a view of the world based on his/her experiences.

In this paradigm, the basic elements of design activities are actions, and the kernel of the design ability is to make intelligent decisions about those actions. The results of these experimental actions are scrutinised by the designer, who reacts to this new state of his/her own making. The final design is a result of this interaction. In this 'reflective conversation with the situation', designers work by naming the relevant factors in the situation, framing a problem in a certain way, making moves toward a solution and evaluating those moves.

In discussions we noticed that this latter term, 'evaluating', is confusing, because it is generally used when evaluating the content of a design solution, like evaluating an idea or selecting a design principle. For the evaluation of actions (the sense in which 'evaluation' is used here), the term 'reflecting' is more common. To avoid this confusion in our further discussion we will use the term reflecting. This also perfectly matches Schön's own terminology of reflective practice.

7 **Dorst, K and Dijkhuis, J** 'Comparing paradigms for describing design activity' *Design Studies* Vol 16 No 2 (1995) pp 261–274

A further point on terminology: please notice that although Donald Schön's theory is often called 'reflective practice', it is concerned with more than just reflection. Four different kinds of design actions exist, and we are interested in the occurrence of all four of them, and in the flow of how they are used by the designers.

2 *A team protocol study: the Philips Design Competition*

When we want to investigate the occurrence of reflective practice in team designing, our first goal is to look at the occurrence of the four activities and to see whether we are able to distinguish them. To study their interplay, the way designers use these actions, we have to look at a design project that is as close to real life as possible, without the deformations that might be caused by an experimental setting. And we need 'rich data' as a basis of our 'rich' descriptions: we must be able to follow all the communication within the team. We have used video to tape the designers at work, and we did a protocol analysis of the teams dialogue for this.

The observed teams participated in a student design contest. In two days they had to develop a conceptual design, working together in one room. We were able to videotape the whole two days of co-operation (an advantage of this competition setting over most real life situations, where a team in a design office always works on several projects in parallel, and does not communicate about a single project all day). The fact that these particular designers were students does not really influence the very general and explorative conclusions of this study.

The Philips Design Competition (PDC) is an annual competition for students from all the Dutch Universities of Technology, that aims to be a simulation of a design problem in professional engineering practice. Nine multidisciplinary teams of four students compete in designing for 8 days, building and testing a smart product that has to perform a specific task. In 1996 the assignment was to design and build a remote controlled robot that has to transport as many balls as possible from a competition table into a basket, placed 1 m from the table (see Figure 1). The parts that can be used to build the products are limited, and provided in a toolbox; electronic components can be chosen and ordered from a restricted list.

The design task is divided in three parts. First there is a two-day design weekend in a studio, where the design team has to establish the design concept. This concept has to be presented to a team of experts at the end of the second day. In the second part, a 5-day building week in a workshop, the design has to be materialised. Finally, on the eighth day, the design is

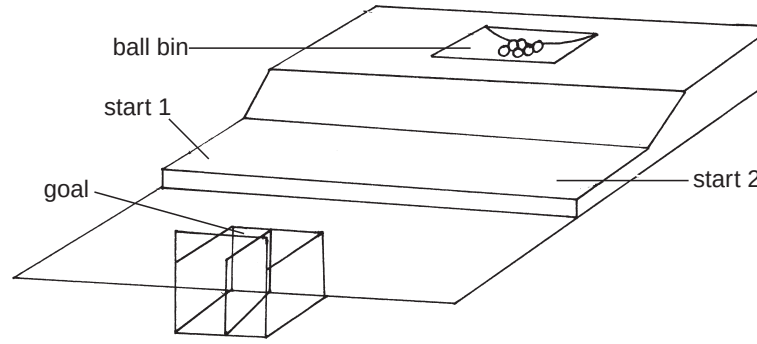

Figure 1 The competition table for the PDC'96. The remote controlled robots compete in pairs and have to transport as many balls as possible from the ball bin into the basket

tested in a knock-out race, where the robots compete in pairs on the competition table. The winner of each round is the robot that, after 3 min, has put the most balls into the basket. After a series of rounds the winner is named.

2.1 The observed teams

Our observations concern the conceptual design activities of two teams, which we captured on video. The building week in the workshop was only recorded with observation lists, that contain the actions and activities of the team members through the work place, and audio recordings of conversations among three or more team members. In this paper we primarily focus on the first 2 days, spanning the conceptualisation of the design, and ending with the presentation of the design concepts to a team of experts at the end of the second day.

The first team consisted of four students coming from three disciplines; one from industrial design engineering (a product designer), one from electrotechnical engineering and two from mechanical engineering. They named themselves 'The Delft Pitchbulls' after the principle of their design (shooting).

The second team also consisted of four students with three different backgrounds; one from industrial design engineering, one from mechanical engineering and two from electrotechnical engineering. They named themselves 'Tecc', after the building material from the tool kit. Their product is called 'Tecc-man'.

We choose these two teams out of the total number of nine participating teams, because of the resemblance in composition (knowledge and experience) and motivation. Both teams are multidisciplinary, composed of the same three disciplines and they have one nearly graduated industrial

design engineering student. These industrial design engineering students both participated in a qualifying workshop in Delft, where they were members of the same design team that won the competition of that workshop. The team members of The Delft Pitchbulls and Tecc knew each other vaguely before participating the Philips Design Competition, but had never worked together as a group before. Both teams were highly motivated to win the Philips Design Competition.

3 *The reflective practice of the teams*

We will now describe the design activities of the two teams using a description method based on Schön's reflective practice theory. Figure 2 visualises the four activities (naming, framing, moving and reflecting) and their relations: the 'mechanism of reflective practice'. The designers start by naming the relevant issues in the design situation, framing the problem in a certain way, making moves towards a solution, and reflecting on those moves and the current frame.

Reflection is a conscious and rational action that can lead to reframing the problem (when the frame is not satisfactory), the making of new moves, or attending to new issues (naming, when the reflection leads to satisfaction).

We will visualise the design projects of the teams during 2 days using this mechanism, to see how the teams in practice manage the four activities and what flow of activities occurs from that.

3.1 *Coding the teams' activities*

Schön's theory of reflective practice focuses on activities within designing. In order to apply the description method to the data we have to distinguish

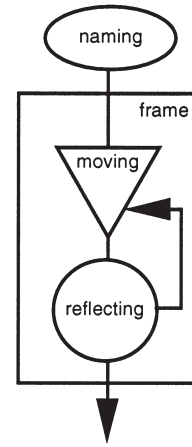

Figure 2 The mechanism of reflective practice; the four design activities and their interplay

these separate activities. To do this the protocol is first divided into 'episodes'. An episode is a part of the protocol in which one activity occurs, for instance the team discusses one subject (like a solution or materials) or acts with the same goal (generating ideas, creating an overview of ideas).

The use of these coherent episodes as the raw data to use the description method on is an essential departure from the traditional way of coding protocol data, using standard time-intervals[6,8,9]. The resulting description focuses on the succession, the 'flow', of activities within the team.

In order to recognise the four different activities we have to look at what the team is doing and which goals they have in mind.

When the team is explicitly pointing to parts of the design task as being important, we code the activity as 'naming'. During the naming-activity the team is looking for relevant objects in the design task.

When the team frames a (sub)problem or (partial) solution to explore further on, then we code the context as a 'frame'. The frame is a context for the next activities; something to hold on to and to focus on while designing. Therefore a frame is mostly only recognisable through the following activity. In an earlier representation we visualised 'framing' as an activity and therefore as a separate box. In further analysis we noticed that the essence was the 'context for further activities'. Then a frame can best be visualised as a box in which other activities can occur (see Figure 2).

Experimental actions like generating ideas, making an inventory, sorting information, combining ideas, or comparing concepts are coded as 'moving'. During the 'moving'-activity, the team not only tries to solve the problem, but at the same time also explores the suitability of the frame. The move is always characterised by a verb, identifying the activity, complemented with the content of the activity.

An explicit reflection on earlier activities to know what to do next is coded as 'reflecting'. The 'reflecting'-activity contains a critical reflection of the team on their earlier actions.

Within the description method of the teams' activities, we added another classification (see Figures 4 and 7). Vertically we plotted the activities of the teams as described above, and on the horizontal axis you will find the subfunctions of the design task, as divided by the design team. This addition to the structure of our description method shows the overview of the subjects the teams attend to and gives some added insight in the teams' strategies for approaching the design task.

8 **Christiaans, H H C M** *Creativity in design* PhD Thesis Delft University of Technology (1992)
9 **Blessing, L T M** *A process-based approach to computer-supported engineering design* PhD Thesis University Twente (1994)

3.2 *Example of the coding*

To demonstrate the coding of the teams' activities, we will reproduce a part of the protocol of Tecc and explain the relation between the protocol and the description of the team according to the mechanism of reflective practice. We choose this particular part of the protocol to demonstrate the coding, because it contains all four activities and various relations between them.

Please note that this protocol is a translation of a Dutch design team, and that a faithful translation of a transcribed protocol is nearly impossible. The designers express their thoughts and ideas in ambiguous words and (incomplete) phrases that are hard to translate into their English equivalents. The translated text is therefore not very dependable: many of the subtleties of the language are lost in the translation process. Therefore the presented transcript has limited value outside the context of this study. These problems did not affect our original data processing, since that was all done in Dutch.

Another point of attention is that the written-out communication does not contain information on the importance the team attaches to the individual utterances. Sometimes utterances that may seem important are ignored by the other team members. Our analysis of this data is based on the videotape itself, in which it is clear how much importance is assigned to an utterance within the team design process. To conserve some of these emphases in this protocol, we printed the most important utterances in bold.

The protocol* contains the first half hour (Tecc, Saturday: 14.03–14.30) of designing.

Et1: "How shall we approach this?"
Et2: "At best we can do idea generation. So everyone writes in a few minutes a number of ideas for the first item on his own sketch pad and then we circulate the sketch pads and someone else does the next one."
Me: "Yes, but..."
Et1: **"Yes, but the first solution is to divide in suitable subproblems."**
Et2: "We already did that."
Me: "Did we do that already?"
Et2: **"Yes, driving the product, collecting the balls, shooting the balls..."**
Me: "We need two ways to drive..."

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*'Et' indicates the Electrotechnical engineering students (1 and 2), 'Me' the mechanical engineering student and 'Ide' the industrial design engineering student.

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Ide: "**I suggest we start with shooting,** that's what it's all about..."
Me: **"Let's get a part."**
Ide: "**...then** look at how to fill the shooting mechanism"
Me: "Yes, shooting, driving..."
Et2: "Driving the product, collecting the balls, shooting the balls...."
Me: "The rest is no use"
Et1: "Remote control perhaps..."

Et1: **"We'll begin with the part shooting the balls."**
Ide: **"Yes we will"**
Et1: "How much time per idea?"
Et2: "I think we must try to draw five concepts each. We'll divide the paper in length in four pieces... or five?"
Et1: "Four is enough."
Et2: "Paper divided in four."
Et1: "Do you want to handle all parts at once?"
Et2: **"No, only shooting."**
Me: **"We'll begin with shooting and see about the other ones later."**

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*during the **"idea generation"** (14.05–14.11) everyone is working individually on his ideas*
Ide: "Well, everyone has something on paper, hasn't he?"
Me: "mm, yes."
Ide: "Shall we that everyone tells...explains his drawings?"
Me: "Yes, you'll start."
***one by one they explain their ideas** (14.11–14.18)*

Me: "let's get to the next one. On the one hand we can..."
Et2: "Yes, how do you want to proceed?"
Me: "Well, eh... For example draw the little cart so we have some ideas on that as well, and then we can start combining. You always have a chance that later on you get something that provides you from applying this....so..."
Et2: "I think more relevant is...eh... how can you collect the balls?"
Me: "That's alright it doesn't matter much... collecting the balls."
Et2: "Yes, or the little cart?"
Me: "That doesn't matter much."
Et1: "The sequence doesn't matter, it's fundamentally independent."
Me: "Yes precisely, collecting the balls."
Ide: **"I think we should continue this..."**
Me: "...that we, in any case, cross some out?"
Et1: "...think further on the shooting perhaps??"
Ide: **"I mean, yes,...because... we've got all this solutions with tubes and so, but this isn't all there is..."**

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Me: *(inaudible)...*
Ide: **“Yes, do we have to shoot? That’s another thing isn’t it?”**
For a minute everyone is silently muddling; Ide reads and draws an idea.
Ide: **“Shall we also think about.....because I drew this idea that has nothing to do with shooting. You can also bridge this by making something over here... that you fill the tube with balls and then....”**
(further explanation of idea)
Me: “Hey, let’s get on with idea generation, or otherwise we’ll stick to this too long. Let’s first do the other things and then later we know for sure that... or in any case that have a little cart or a chassis, more or less, and then on that basis we can look more in detail...to the...eh...”

Ide: **“No I don’t think so. I think the way you get the balls into the basket, that’s to what you should adjust everything else to, not the other way around.”**
Et2: “**Yes, I think so too.** Driving is driving, that’s plain.”
Ide: “Driving is the easiest part”
Et2: “**We have to find a way to aim the balls from the storage into the basket as accurate as possible.** If we have that, I say OK, then we adjust the collecting to that... because... how can we transport a storage bin with that form...”
Me: **“OK, yes, let’s see that as our main problem for now.”**

The protocol is divided in episodes by the horizontal lines. Each episode can be coded according to an activity in the mechanism. The first activity

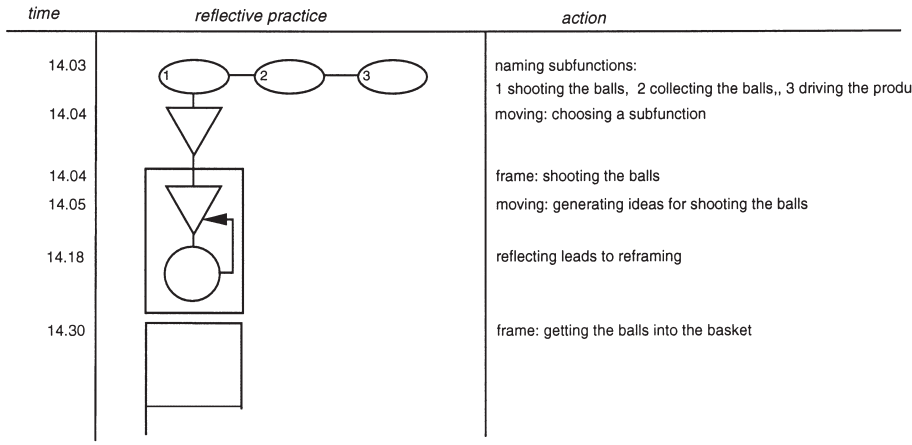

Figure 3 Description of the first half hour of Tecc’s design activities

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of the team is naming relevant objects within the design task; 'shooting the balls', 'collecting the balls', and 'driving the product'. The second activity is moving; choosing the most important name to handle first. The third activity is creating the frame 'shooting the balls'. The next activity is moving; they generate ideas and then discuss them. After this a moment of reflection occurs; the team discusses 'what to do now', 'what do we have', 'is this all', and 'do we have to shoot'? This results in the following activity: resetting their frame into 'getting the balls into the basket' as the most important problem issue. Figure 3 visualises this half hour of the protocol.

3.3 Team 'The Delft Pitchbulls'

The design activities of the team The Delft Pitchbulls are visualised in Figure 4.

The Delft Pitchbulls start Saturday at 14.40. They name the different remote control functions they have to design; 'shooting the balls', 'collecting the balls', 'steering' and 'driving'. One team member tries to challenge the 'shooting' principle with other solutions to get the balls into the basket, but they are rejected right away. Then the team starts with how to sort the balls after having collected them. They attend to the tactics of the game; they try to imagine what to do when the competition starts. During the following discussion the team handles many items in parallel. For instance they consider the provided motors and which one to use for which function. They decide on a pitcher, and think about how to sort the balls into the pitcher, also every now and then attending to tactics during the game. They try to find solutions for the subfunctions. It often occurs during discussions that although they come up with detailed solution possibilities, they continue with another subject without making a decision and without explicit elaboration of the (sub)idea.

At 16.45 they begin to make an inventory of the chosen subsolutions; a pitcher for shooting the balls, a shovel for collecting the balls, the different control functions integrated in the remote control, caterpillar tracks for driving, and a global lay out of the chassis. This making of the inventory is interrupted by a discussion on the shovel until the end of the Saturday session.

Sunday morning they continue in the same way, with handling all relevant aspects of the subsolutions of the product in parallel. At 12.31 they decide to choose the materials that are necessary to build the product and they draw a lay out of the chassis. Right after lunch (13.43) they make a drawing for the presentation to the team of experts.

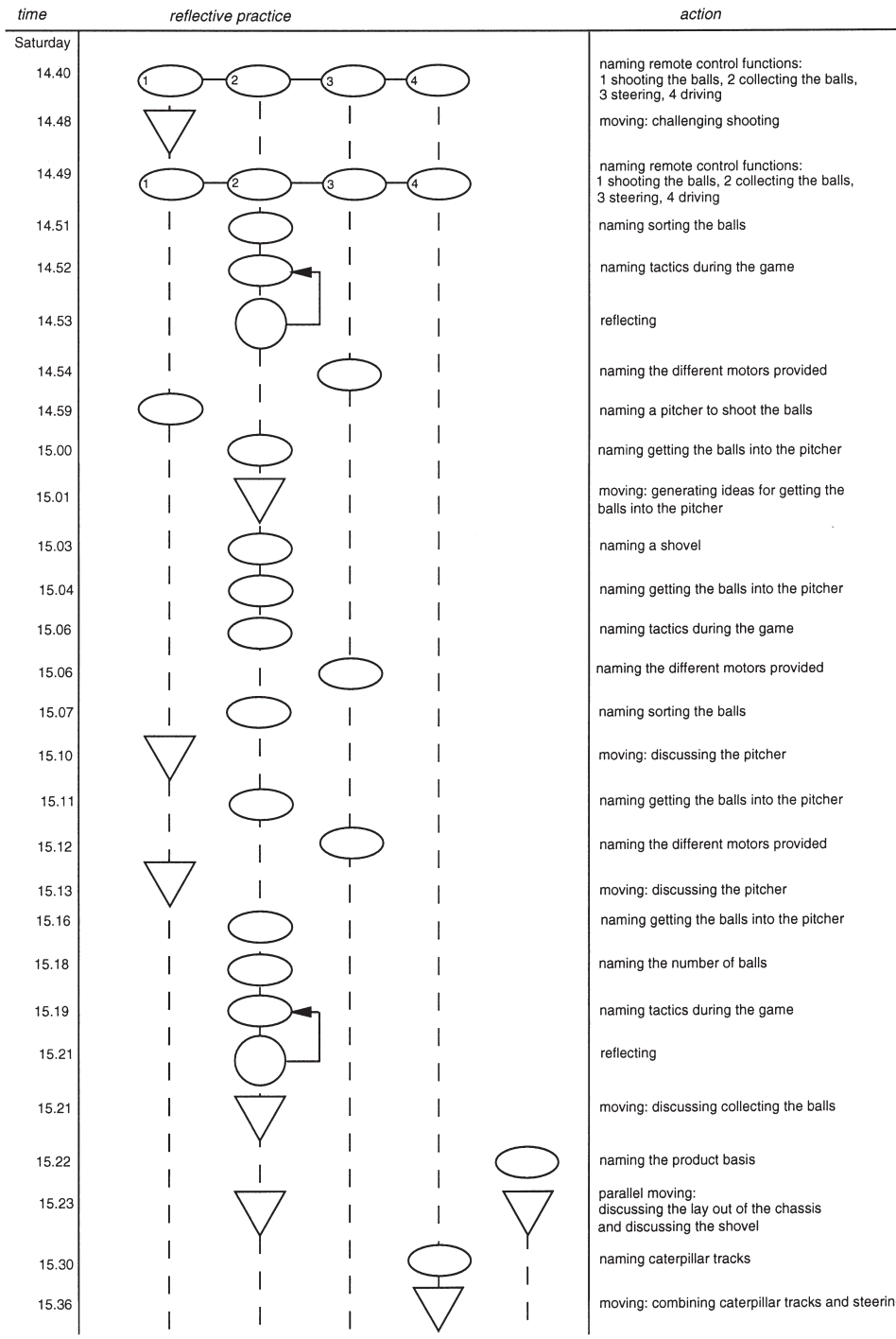

Figure 4 The design activities, according to the 'mechanism of reflective practice', of team The Delft Pitchbulls

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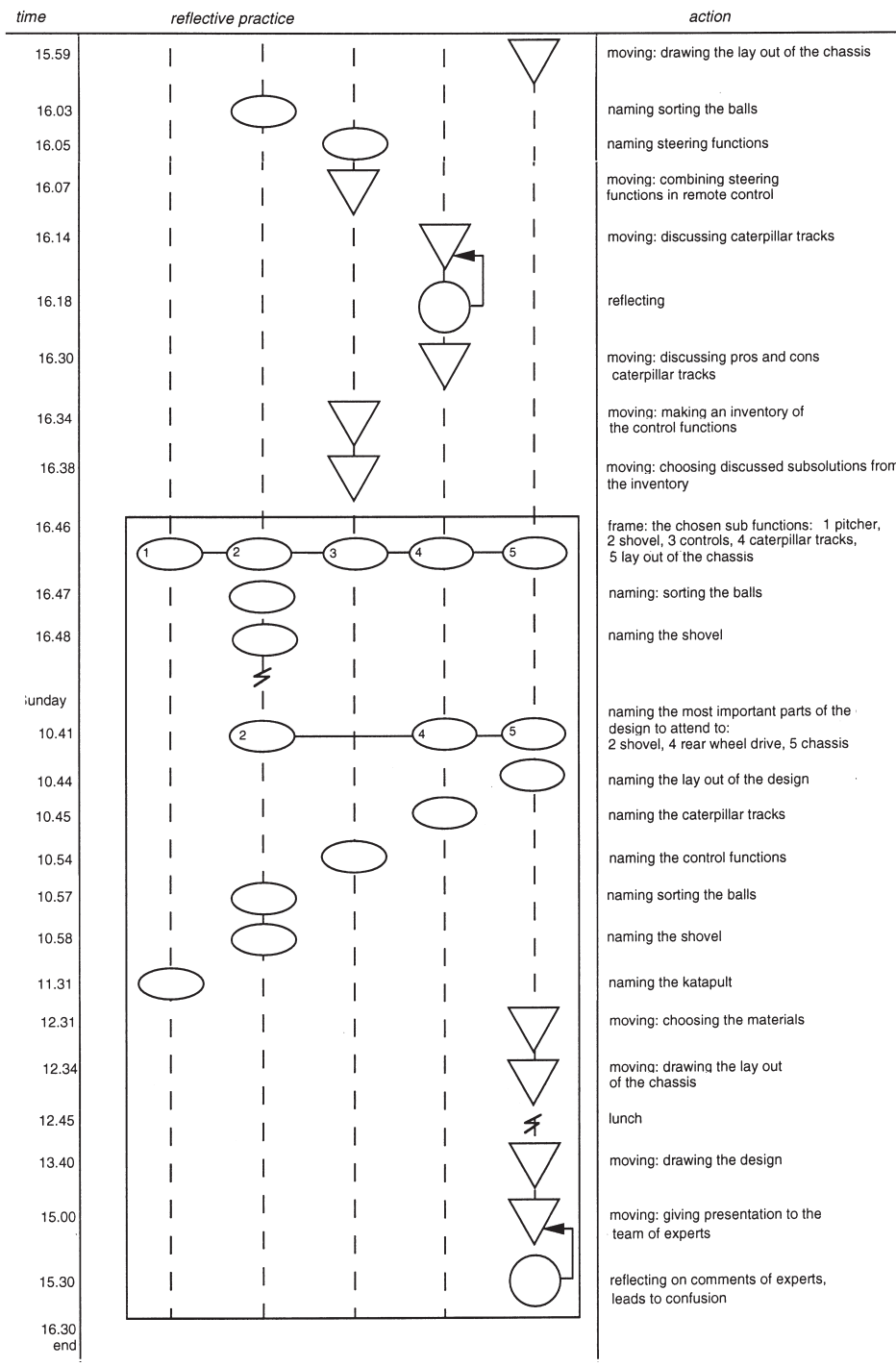

Figure 4 Continued

From 15.15 until 15.30 they present their product to the team of experts. The drawing they used is reproduced in Figure 5. At 15.36 they return to the design studio and try to recall the remarks and questions of the experts. In the discussion that follows they can't understand the problems that the experts pointed out and the rest of the Sunday they are not working on the design. The final design on the day of the competition is shown in Figure 6.

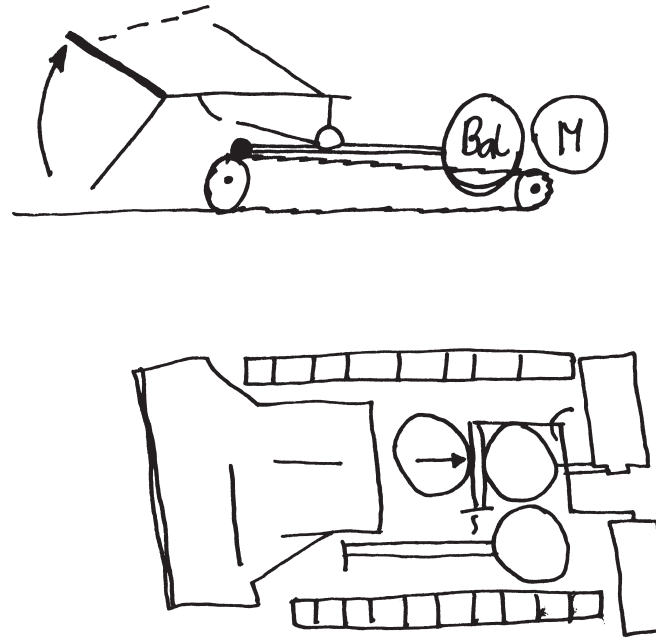

Figure 5 The design result of The Delft Pitchbulls, as they presented it to the team of experts

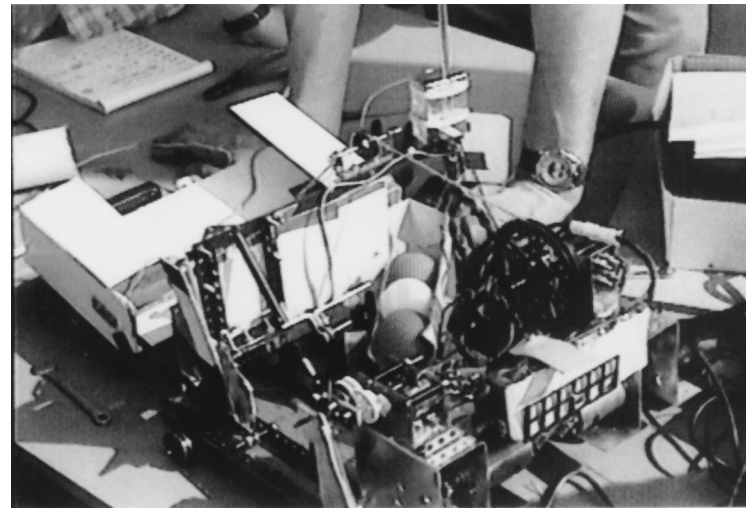

Figure 6 The final design of The Delft Pitchbulls

3.4 Team 'Tecc'

The design activities of the team Tecc, according to our mechanism, are visualised in Figure 7. Tecc starts Saturday at 14.03. They decide to generate ideas on the subproblems and they start naming different functions of

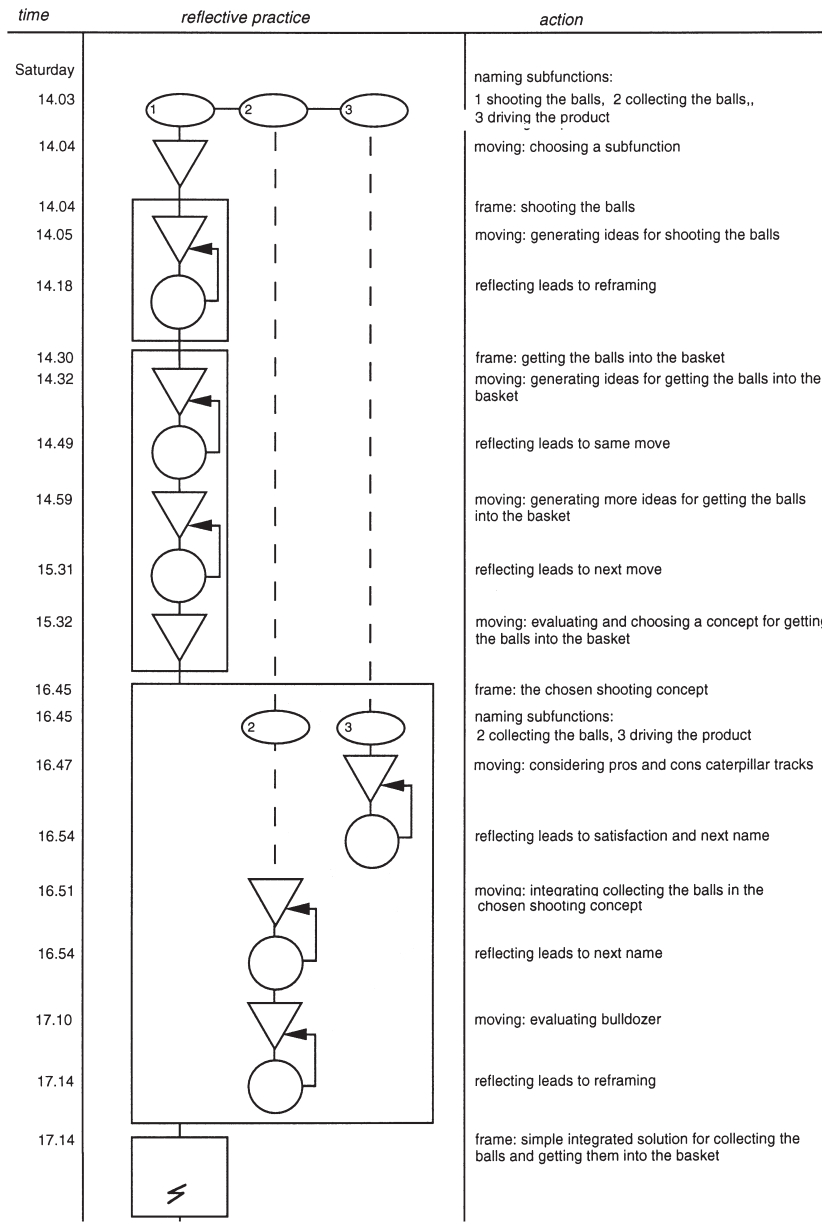

Figure 7 The design activities, according to the 'mechanism of reflective practice', of team Tecc

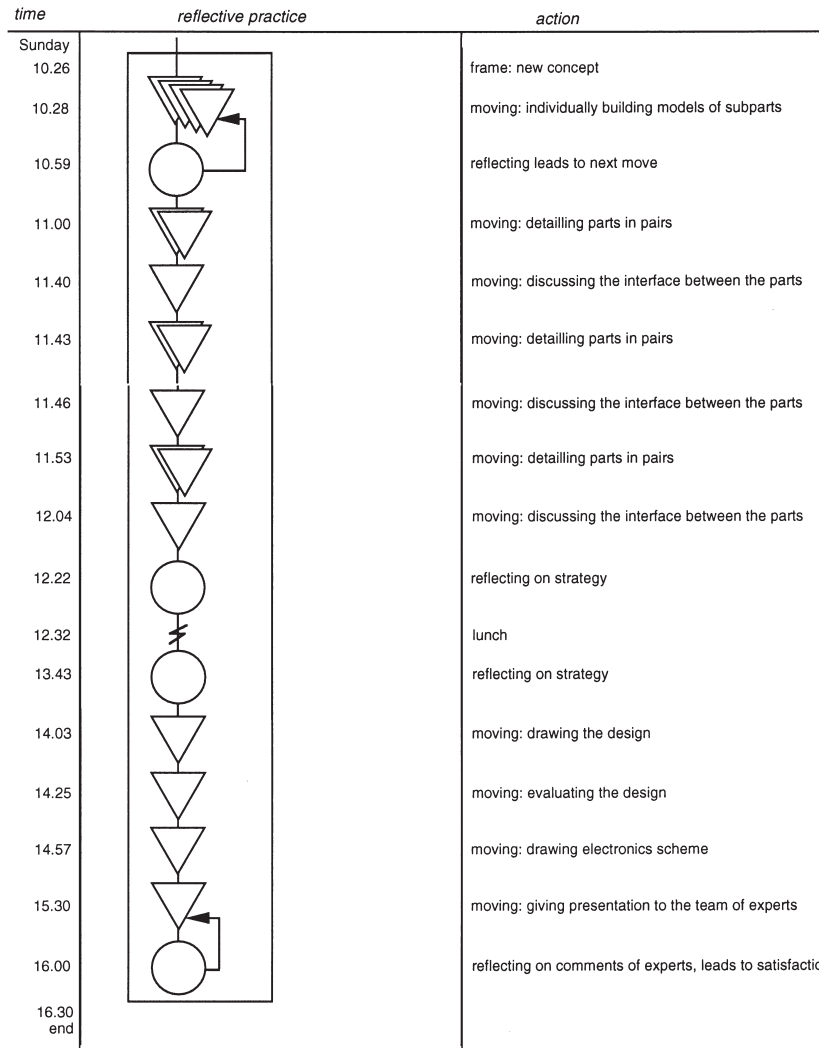

Figure 7 Continued

the product to define these subproblems. They divide the problem area into 'shooting the balls', 'collecting the balls', and 'driving the product'. They choose 'shooting' as the most important one, and start generating shooting principles. The first reflection moment occurs at 14.18, after generating ideas individually and discussing these ideas in the team. The team discusses which name to tackle next, 'collecting the balls' or 'drive the product'. Then they discover that 'shooting' is not the only way to get the balls into the basket. They reframe this subproblem as 'getting the balls

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into the basket' and generate ideas on 'bridging-' and 'through the canal-' solutions. After generating ideas twice, they collect all the ideas, formulate selection criteria and start evaluating the ideas and selecting one (15.32–16.45). At 16.45 they frame the chosen shooting concept and recall their remaining names 'collecting the balls' and 'driving the product'. They start a discussion on the pros and cons of caterpillar tracks for driving, and decide to test them in a model on Monday. Their next experiment (16.51) is aimed at integrating ideas on 'collecting the balls' in their chosen shooting concept. After only 5 min they decide that the design concept is becoming too complex and discuss how to continue. They come up with a simple solution, a bulldozer, to collect the balls and just throw them in the direction of the basket; a simple product, but an uncontrolled action. After reflecting on their designing and the way their solution is heading, they decide to concentrate on an integrated solution for collecting the balls and getting them into the basket and keep this solution simple. With this new frame they conclude the Saturday.

Sunday morning it is obvious that the team has worked for another hour the evening before. They designed a new concept with which they start on Sunday morning. They separate this concept in subparts and every team member builds one part to test. At 11.00 after testing the (very preliminary) models, they confirm the chosen concept and divide the task in two large pieces, to work on in pairs. Until lunch (12.32) they work in pairs, every now and then discussing the interfaces with the whole team. After lunch they draw a picture of the product for the presentation to the team of

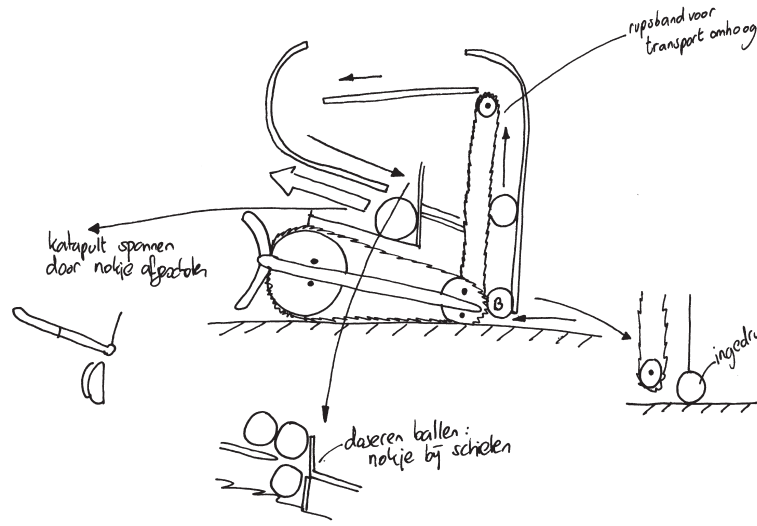


Figure 8 The design result of Tecc, as they presented it to the team of experts

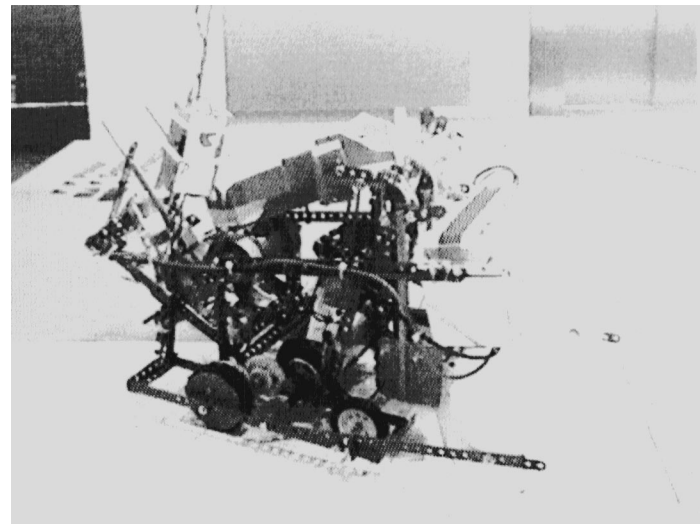


Figure 9 The final design of Tecc

experts. They evaluate their product and draw up a list of good and weak elements of their solution.

From 15.30 until 15.45 they present their product to the team of experts. The drawing they used is reproduced in Figure 8. After having heard the remarks and considerations of the experts, Tecc makes an inventory of the main comments of the experts and decides what to do with it. The design weekend is closed on Sunday at 16.30. The final design on the day of the competition is shown in Figure 9

4 *Discussion on implications for team designing*

Schön introduces his theory using the metaphor of 'design as a reflective conversation'. He describes a design activity as being controlled locally, and does not deal with higher level strategies. However, applying the detailed mechanism of naming, framing, moving and reflecting onto a total design project reveals large-scale strategies. The description of both teams reveals a large difference in the strategies the teams use. The remarkable differences in the patterns of behaviour of both teams arouses an interest in deeper analysis.

The Delft Pitchbulls handle different names simultaneously through the whole project, representing all relevant aspects of the design task as they see it. They divide their attention over all aspects and interrupt each other whenever they get deeper into one subject, arguing that another subject is also important to attend to. They are searching for the one best solution to fit the problem, but without generating any alternatives. The subsolutions they decide on are not compared to other ideas, or being developed from

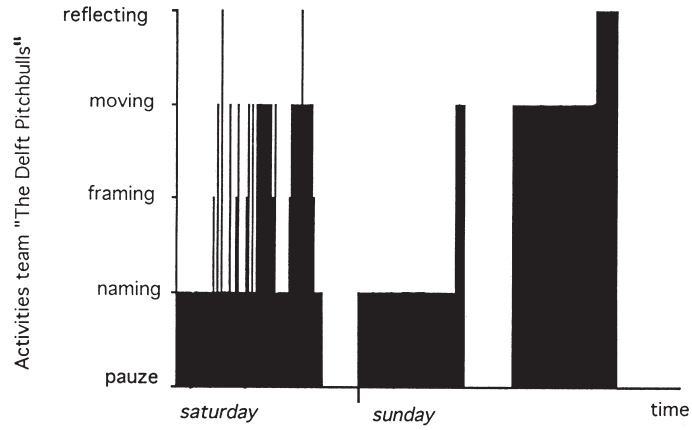
idea to working solution, but are simply chosen as being the best ones. In the drawing of their design (Figure 5) The Delft Pitchbulls present the design as four subsolutions. When the team of experts asks for the links between the components, the team can't give them an adequate answer, because they lacked time to design the integration of the subsolutions.

Tecc, on the other hand, determines a frame, concerning that what they see as the main aspect of the design task, from the beginning of the design project. They develop that single frame throughout the design project. They try to integrate new aspects of the design task in earlier frames (and subsolutions) and, in this way, build an integrated view on the design task and the design solution. Looking at the drawing of the team's design (Figure 8) we can see that Tecc presents the 'working' of the machine by indicating the path of the ball through the machine.

We only described the first design weekend of the Philips Design Competition in this detailed manner, but we did observe both teams for the rest of the week. At the actual competition, a week later, The Delft Pitchbulls didn't have a working robot. While building the design in the workshop, the problems that occurred within the subparts of the design took all their attention and the integration between the shovel and the pitcher still wasn't working at the end of the week. Tecc won the Philips Design Competition '96. They built their design in 2 days and used the rest of the building week for testing and improving the product.

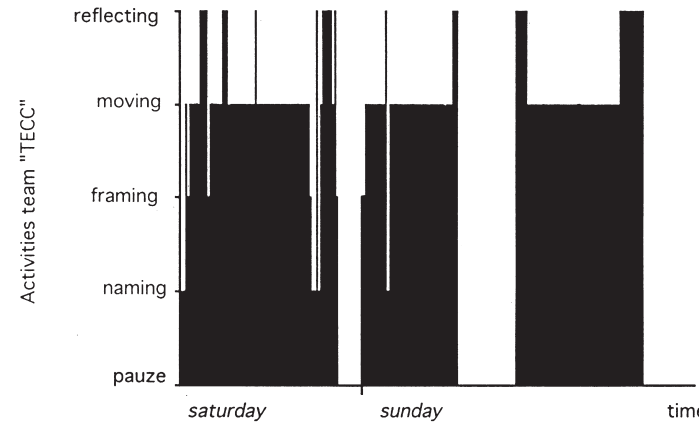
Of course we could never have imagined studying both the winning and a loosing team, or hoped for it, when we selected the teams at the start of the competition. However the achievements of the teams compared with the large difference in the teams descriptions, provides enough encouragement to continue observing and analyzing team designing in this way. The Schön-based description method we created seems an interesting instrument for describing team designing and identifying occurring strategies and problems.

Figure 10 shows the relative time both teams spent on the different design activities. The main activity of The Delft Pitchbulls is 'naming'; by dividing their attention over all aspects of the design task and interrupting each other whenever they get deeper into one subject, they get stuck in this activity and therefore little changes in the design content. The moves The Delft Pitchbulls do make are 'generating ideas, discussing different items, making an inventory of sub-solutions, choosing materials and drawing the chassis and the product'. Only after stating the frame of the chosen subsolutions their moves become concrete, like 'choosing' and 'drawing'. Before that their moves are mainly 'discussing'.



effective design time: 7h 45 min	naming	framing	moving	reflecting
	49 %	4 %	39 %	8 %

(a)



effective design time: 8h 30min	naming	framing	moving	reflecting
	3 %	3 %	73 %	21 %

(b)

Figure 10 The design activities against the time the teams spent on them. (a) reflects the activities of The Delft Pitchbulls, (b) those of Tecc

Tecc spends most of the time on 'moving' (73%). The moves are where the actual designing takes place; when the team is really handling and changing the design content of the project. The moves Tecc makes are 'choosing ideas, generating ideas, considering arguments, integrating parts, evaluating ideas, building models, detailing parts, consulting on interfaces, drawing the design, and evaluating the design'.

Moves without a frame lack a shared goal of the activity to aim the teams' discussion. Whether that lack of focus (within a concrete frame) hampers the progress of The Delft Pitchbulls will be examined in a subsequent paper.

Tecc spends 21% of the time on reflecting. The Delft Pitchbulls 8%, but mostly at the end of the project, initiated by the comments of the team of experts. Then the reflection is too late to intervene in the project and The Delft Pitchbulls don't really know what to do with the outcome. Tecc mostly reflects at the beginning of the project (on Saturday), and does so frequently and in brief periods. Reflection is crucial in designing, because by reflecting on its behaviour a team of designers can rationally make a decision to start a new activity.

The reflection moments of The Delft Pitchbulls are aimed at their last activity and concern a choice to make for the next activity. The Tecc reflection moments always occur in relation to the design task and the team's progress. This difference in 'scope of reflection', that might be caused by the missing of a frame, will also be examined in a subsequent paper.

The building and development of frames seems important. The time spent on 'framing' doesn't indicate much, it is more important to note that Tecc uses five different frames sequentially during the project and The Delft Pitchbulls one. The development of frames (both stating a frame and modifying or rejecting it again) seems important in building an understanding of the design task and its solution.

In the description of the frames used we can make a distinction between frames concerning the design task (the problem) and frames concerning the designed solution(s). If we do this for both teams we can see that Tecc first explores the design task, before choosing and developing the solution. The Delft Pitchbulls almost immediately start searching for the solution, without exploring the design task. The interaction between working on the design task and solution, and trying to gain an understanding about them will be analyzed in more detail.

5 *'Reflective practice' as an observation method*

Although Schön never intended it as such—he describes design as being controlled locally, without dealing with higher level strategies—the description of team designing in episodes and categorizing them into the four activities provides a good insight in the course of the team design on a project level. Coding in episodes is also evidently efficient; we have

made a succinct description of almost 9 h of designing, without losing too much information, and without losing the overview of what is happening.

However, identifying the teams' episodes and activities with this method is easier if the team itself works in a structured way. Obviously, when describing design practice, researchers rely more or less on the structure in the ways of working of their research objects.

In describing the activities the researcher has to make a decision about the level of detail he/she wants to obtain. We, in this research, chose to divide the protocol into episodes in which the same activity occurs. In this way we can describe moves like 'generating ideas' or 'choosing a concept' (Tecc Saturday 14.32–15.49 and 15.32–16.45). However it may be useful to distinguish episodes by the objects the teams attend to. Then we can divide the two examples into moves like 'generating idea x', 'generating idea y', etc., and 'formulate requirements', 'evaluating idea x', 'choosing a concept'. According to his/her research goals the researcher has to establish the needed amount of overview versus detail within the description of the activities.

This way of describing team activities provides a good framework for discussion on team designing. In education it can be very useful to either illustrate design professionals-in-action or to confront design teams with their own practice.

As a research method, describing design-teams-in-action with Schön's reflective practice is useful and clarifying, because the description provides a good survey of the course of the project. Going from this 'global' description we can start analyzing the different activities in more detail, analyzing the teams' behaviour.

At the end of the design weekend we immediately marked in our notes the moments in the project where we thought something interesting was happening. Comparing those marks with the later generated descriptions of the teams, all the interesting moments occurred when the team makes a transition between frames. The view the team creates about the context they are working in seems very important in team designing. The descriptions and analyses of the design teams structure research into design behaviour; they provide a framework for the entire process instead of interesting moments.

6 *Further research*

Our goal in this explorative study (and Schön's goal in introducing the theory of reflective practice) is to develop tools and guidelines for team

design practice and to improve education for design practitioners. However the mechanism of reflective practice and the two case studies described in this paper are just descriptive models of design. The descriptions provide a clear view of team strategies, and as such they could be of use in design education. But to improve design theory and education systematically we need to make a transition from this pure description to prescription. We need to further analyze and discuss the general patterns that occur in the described teams. Looking in-depth at the data the above statements might be refined into hypotheses, that should then be tested in future experiments.

The description method, as we used it, works with these teams in this situation. But because, as we stated before, researchers depend to some extent on the structuredness of their research objects, we can't yet be sure about the suitability of this description method for other teams. We have to make descriptions of more teams in other design situations. In order to be able to explain the research method in more detail, we will use team protocols that are very well documented in the design research community; the two group design sessions of the Delft Protocol Workshop[10]. Describing this particular team will also give us the opportunity to compare our research method with that of many others, already applied to this protocol.

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10 Cross, N, Christiaans H and Dorst K (eds) *Analysing design activity*, John Wiley & Sons, Chichester (1996)