

RE-DESIGNERLY WAYS OF KNOWING*

TOWARDS A DEEPER UNDERSTANDING OF REDESIGN

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ABSTRACT

This paper describes a study of the design process of architects dealing with building reuse. Even if we can intuitively recognize that the redesign of an existing building is different from the design of a new one, it is not easy to point to the distinguishing aspects of redesign and to the way architects cope with them. In order to shed more light on redesign, the paper starts by describing the general framework of the research, after which the protocol of a redesign session is analysed in two different ways. First a qualitative method is used to discuss the contents of the design session. Subsequently, a quantitative method is used to perform a more detailed analysis. The conclusions of both analyses are discussed at the end of the paper.

1. INTRODUCTION

Current architectural discourse has entered into a growing debate about reuse, challenging architects more and more to redesign existing buildings. Many reasons can be found for this tendency, but in general, there seems to be a common acceptance of the added value of reuse, as compared to replacing a building. Intuitively, we can recognize that a design for an existing building is different from the design for a new building. But what are the distinguishing aspects of redesign? And how do architects cope with them? For more often than not, architects are not specifically trained to redesign buildings.

Because of the large number and variety of knowledge areas involved, architectural design is known as a highly complex activity. Dealing with an existing building makes it even more complex: the building to be redesigned can be viewed as an enlarged 'context' for the design project. In addition to the site and its surroundings, the building is an additional element to take into account, with its own history, its own physical properties, its own economical, cultural, and social values. All these factors influence decisions taken by the architect considerably. In order to tune the intervention, the designer must not only meet the demands of the client, but also match every decision with the existing building, its possibilities and its difficulties. At the same time, the existing building may provide clues for the design that designers of new buildings must do without.

Investigating the path architects followed during redesign can reveal some of the underlying mechanisms behind 'redesigning'. By enlarging the understanding of these mechanisms, we hope to help both (novice) practitioners and design educators in performing or teaching redesign.

2. RESEARCH FRAMEWORK

The study described in this paper is framed within a larger research project that investigates the use of design strategies, the application of design methods and specific aspects of design thinking in case of redesign. For this project we have opted for a 'mixed method' approach. By examining redesign in various ways and from multiple perspectives, a richer understanding of redesign can be achieved and the results of the sub-investigations can be 'triangulated'.

* After Nigel Cross' famous article 'Designerly ways of knowing', *Design Studies*, Vol.3, No.4, 221-227.

The first stage of this project consists of an experiment in which protocol analysis was applied. The experiment was originally set up for testing the prototype of a design tool called 'DYNAMO' (Heylighen & Neuckermans, 2000). DYNAMO—Dynamic Architectural Memory Online—is a multimedia platform developed to support architects during design through concrete design cases. Because the design task used in the experiment involved the redesign of an existing building, this experiment is 'reused' in our research.

Four architects—two junior and two senior designers—were invited to develop a concept for the reorganization of and extension to an architecture school, which is located in a 16th century castle (see Figure 1).



Figure 1. West wing of the 16th century Castle of Arenberg

Both juniors had five years of experience as practising architects, their senior colleagues 13 and 19 years respectively. Although not 'world-famous' architects, the seniors can be considered expert designers in that their work has attracted major design awards and/or won important competitions.

The design task involved the reorganization and optimization of the West wing of the castle (design studios, lecture rooms, secretariat and photocopy room) and the extension of it with a reception hall, material museum and exhibition room. Small scale plans of all floors and pictures of the outside of the building were available in the experiment room. All four designers know the building quite well: three of them studied here and two of them are currently teaching in the school.

Apart from having access to DYNAMO, the architects could go about the task as they preferred. Two restrictions resulted from the method used: they were asked to 'think aloud'—by saying what they are thinking of, a large part of the design process can be externalized—and the design session was limited to two hours. During the session all actions of the designers were audio- and videotaped. Afterwards the drawings and notes were collected and numbered chronologically. Only three architects finished the session. The fourth left the experiment in an early stage, because she found designing in front of a camera too stressful.

This paper describes the analysis of one of the three resulting protocols. Since the path of only one designer is investigated here, it is obvious that no general conclusions can be drawn yet. Most probably some aspects of this protocol will differ from those of the other designers. It is nevertheless important as preliminary work in developing a more profound understanding of redesign, as it enables us to pose, extend and fine-tune research questions about this topic. For this preliminary analysis protocol #2 was used because the quality of the audio- and videotapes was higher than of those of the other two. After the session, the tapes were

transcribed and the transcription was supplemented with a description of the architect's activities.

3. GENERAL QUALITATIVE ANALYSIS

In order to get an overview of the contents of the design session, we started with a qualitative analysis of the protocol. Figure 2 offers a summary of the transcribed data of the session; Figure 3 lists the main remarks and decisions of the architect.

After transcription, we first made a coarse division of the protocol into segments wherein the architect considers one topic. This topic is never exclusive, but in each segment we can recognize a main topic guiding the thought of the designer. Four main topics are distinguished in this design session: the program (P); the location of volumes, their relationships and the circulation between them (L); the appearance of the building and the materials used (M); proportions and shapes of the volumes (V).

Thoughts about other topics interfere from time to time in these segments, without overtaking the main idea. At several times the architect starts talking about the history of the building, he also mentions economic considerations and structural aspects appear randomly throughout the whole session.

Sometimes reasoning about one topic fluently flows into reasoning about another topic. At other times we can recognize a clear transition between two segments, when the architect is considering how he should proceed with the next step. This could mean that an argumentation for the design is sometimes built up while being almost unaware of the path followed to do so. At other times, the designer makes a conscious choice which he thinks will lead him in the right direction.

Apart from this segmentation, Figure 3 summarizes major remarks and decisions the architect takes. A distinction is made between remarks (R) in the design session that are 'logically derived' from the brief or the existing plans and pictures, and decisions (D), choices made by the architect based on his own preconceptions. Decisions in bold can be considered as crucial for the design. Without these, the design would have been considerably different. Although the sketches are not finished drawings, and the design is not complete, all these decisions can be traced in the architect's drawings.

Figure 3 shows that several of the major decisions directly follow from something the architect notices shortly before making the decision. This input of information seems to push forward his design. A number of these decisions are directly based on aspects of the existing building (0:16:51; 0:17:40; 0:23:29). This seems to suggest that the way a building is analysed and what information is available about it influences its redesign considerably.

Several aspects of the design return repeatedly during the design process (use of materials, restoring the staircase, importance of the position of the trees, importance of the entrance, ...). Each time they are nurtured with elements from other considerations, which have emerged meanwhile. It is as if the architect is looking for a justification for the decisions he takes. When an idea emerges from one line of thought, he starts looking for other lines of thought that can support and strengthen this idea. Only when a decision fits in all of them, it is accepted.

Sometimes decisions are very clear, and the architect does not seem to doubt his choice. He does not consider alternatives and does not question his decision later on. At other times he suggests a solution for part of the design and continues this line of thought to find out whether it also offers a solution for other parts. If so, he continues his proposal; if not, it is rejected and another proposal is chosen for evaluation. Still at other times, different possibilities are considered and compared simultaneously.

Topic	Descriptive summary of the protocol
	0:00:00 Start session. Discussion about the course of the design session and the experiment.
P	0:02:44 The architect reads the program brief and looks at the plans of the existing situation. He wants to determine the scale of the plans.
P	0:07:28 He reads the program brief again and focuses on the surfaces of each of the rooms. This way he concludes that the total net surface is 770 m ² , so he needs 1500 m ² in total.
P	0:09:20 After that he examines what is the available surface in the existing part of the building. The conclusion is that 550 m ² is available in the Westwing of the Castle, and almost twice this surface must be provided in an extension.
L	0:13:47 He considers different locations for the new volume, and concludes that the space in between the Castle and the watermill can support a new building. After that he considers the size and the characteristics of this space.
M	0:15:51 Starting from the consideration that he should determine what part of the program will be fit in the existing part and what part in the extension, he discusses the identity of the castle and the extension, and determines the materials and architectural and spatial elaboration.
P	0:19:46 Here he actually starts considering the location of the different parts of the program. Two initial trials are made: the archives could go under the roof, the reception hall on the groundfloor of the West wing, in the former stables.
L	0:22:54 After deciding where to put the reception hall, he discusses the relation of this hall with the outside neighbouring spaces, the inner court of the castle on the one hand, and the space in between mill and castle on the other hand. Also the relation between this new outside space and the extension of the castle. He considers putting the extension next to this place a good decision because it organises the space. He decides to make a more determined qualitative space next to the water, in between the mill and the castle.
	0:26:06 He looks at pictures of the castle to find out historical aspects of the building.
V	0:28:00 He decides that the volume of the extension should appear separate from the castle, should have enough mass (more than one level), and could have a vertical articulation.
L	0:28:42 He considers relationships between inner court, reception hall, the entrance, the new volume and the outer space.
P	0:31:13 Program: argumentation pro/contra location of the archives, material museum and exhibition space. Material museum and archives can be on the ground floor or the first floor, exhibition room on 1st floor? He discussed accessibility for these possibilities.
	0:40:00 Character of the extension: should not be too flat, at least 2 levels. 0: glas, +1: closed, blind, with rooflight. Material museum and archives go on the first level, exhibition room and secretariat on the groundfloor.
L	0:42:34 He discusses the relation of different parts mutually and with the outside.
P	0:51:26 Reevaluation of different aspects of the program: sizes, relations between functions, positions of functions.
P	0:59:43 The circulation in the redesigned parts is discussed. As opposed to what is asked in the program brief, the vertical circulation is not placed in the existing wing, but in the extension. The entrance should not only be an entrance to the building, but form also a link between outside and inner court.
	1:03:17 Recapitulation of previous choices: here the designer redraws his previous choices in a new drawing. This way he reconsiders and then confirms certain choices. This also brings up several new elements that have to be considered.
V	1:10:47 He determines the proportion of the volumes as 25 meters by 15.
	1:13:00 The position and necessity of inner separations, abutments, and beams is evaluated.
L	1:13:48 A pavement behind the building can make a good transition of the workshops towards the grass.
M	1:14:32 The blind façade of the castle lets him choose for a blind volume in brickwork. Under it a complete glazed volume will make it look as if the building is lifted. By providing a one level connection in a separate material between old and new castle and extension will appear solitary. The existing 'back-entrance' should become larger and could have a contemporary shape.
V	1:18:20 He discusses the possibility of a shedroof to provide light and as a possibility to design an articulate structure.
P	1:23:19 Reconsidering the program and offering alternatives for the previously chosen options. Although he rejects all of these options, this way he redefines and refines his previous choice.
V	1:34:18 Reconsidering the proportion of the volume in regard to the latest changes. This is dropped when he is reminded about the fact that he has only 15 minutes left.
	1:35:17 He starts using dynamo to get documentation about structures and daylight.
L	1:40:55 He considers the entrance from below towards the archives and materialmuseum. He decides to keep it closed from below and to create a minimal perforation to go to the upper space.
L	1:42:57 The circulation in this new part is placed in the middle, next to the exhibition room. This way the exhibition can act as an appetizer.
	1:46:22 Continues using DYNAMO, without clear results.
	1:49:38 Stop session

Figure 2. Summary of the protocol

Topic	Description of remarks and decisions
P	R 0:08:48 Total net surface is 770m2, this makes about 1500 m2 in total...
P	D 0:09:26 The two original staircases will be conserved...
	R 0:10:18 By eliminating the new staircase, space can be freed to create a more spacious link with the inner court...
	R 0:11:52 The scale of the given drawings is 1/390...
	R 0:13:03 The surface per level in the existing wing of the castle is 200 m2...
	R 0:13:30 In total, this wing has a surface of 550 m2...
	R 0:13:34 This means that about 1000 m2 will have to be built in an extension to the castle...
	D 0:13:47 The extension will not be built on the inner court, which forms a beautiful architectural ensemble...
L	D 0:14:02 The space between the watermill and the castle can bear a new volume much better.
	D 0:15:32 The character of the existing blind wall should be conserved...
M	D 0:15:55 The 'back-entrance' in this wall should become more important...
	R 0:16:41 The castle has its own identity...
	D 0:16:51 The extension should also have an own identity...
	R 0:17:26 The mill and the castle are completely made out of brick, the roofs covered with slates, the windows cast in lead...
	D 0:17:40 The same materials (brick, glass and lead) should be used for the extension...
	D 0:18:15 Contrast should be made by means of the architectural elaboration (windows, structure)...
	D 0:19:12 The inside space should be one total space to strengthen the identity...
P	D 0:19:46 The existing wing should not be partitioned...
	D 0:19:57 Smaller services can act as a link between the existing part and the new extension...
	R 0:21:31 Placing two parts of the program on the same level in the westwing is impossible...
	D 0:22:14 The reception hall can be placed on the ground level of the existing wing. The arcs towards the inner court can be opened again...
	R 0:22:52 This way the reception hall acts as a link between inner court and the space between mill and castle...
L	R 0:23:29 The south-east side of the castle is sunny almost all day...
	D 0:23:59 It is interesting to create an outside space next to the water...
V	D 0:28:02 The volume of the extension should be separated from the castle, and linked with another volume...
	D 0:28:10 This volume should be at least more than one level to have enough mass...
L	R 0:29:08 There is not much contact from the castle towards the river now...
	R 0:29:45 It is clear that the gates towards the inner court have to be opened...
	R 0:30:09 The relation of the inner court towards the space in between mill and castle can be made : 1. through the building 2. with a direct link; 3. via a hinge between old and new...
	R 0:31:05 Secretariat - photocopy room - counter should be placed on the groundfloor...
P	R 0:31:56 Not much will be placed on the levels this way...
	D 0:33:13 Exhibition and material museum should be placed on the first level in the new building...
	D 0:34:42 The archives should be placed in the new building...
	D 0:35:25 Not all the space in the existing wing has to be filled...
	D 0:37:42 Material museum and archives can be flexible by exchanging space...
	D 0:40:51 Material museum and archives should be placed on the first level...
	D 0:41:06 The exhibition room, meeting rooms and secretariat should be placed on the ground floor...
	D 0:43:25 The workshops should be in contact with the outside space...
L	R 0:52:00 This way the programs on the groundfloor and the first level have the same size...
P	D 0:52:14 This way the extension will be one volume...
	R 0:58:57 The first level in the castle will remain empty...
	D 1:00:14 The hinge between the West wing and the higher parts of the castle will be opened...
P	D 1:01:36 The connection with the extension will be made through the reception hall...
	R 1:02:11 The pavement next to the castle does not need to have the same width than the building...
	D 1:02:16 The building can be inserted into a narrower pavement...
	D 1:10:01 From the reception hall, there should not only be a view towards the inner court, but also towards the space in between mill and castle: 1. an inside view under the toolbox; 2. a outside view on the green
V	D 1:13:13 The inside partitions will be conserved...
L	D 1:15:14 The new volume will have glazing on the groundfloor level...
M	D 1:15:31 The entrance will become a larger contemporary opening...
	D 1:16:57 The connecting volume can be a one level volume, with its own materials...
	R 1:32:45 The archives do not have to be a perfect square space, a museum does...
V	D 1:32:52 the archives can be placed against the blind walls of the box, with the materialmuseum in the middle.
	D 1:43:02 The vertical circulation space can be placed in the middle of the extension...
L	D 1:44:09 The bottom of the material museum can be closed...
	1:49:38 Stop session.

Figure 3. Remarks and decisions in the protocol

Several design strategies are used in this redesign process. Very early in the session, the architect declares that the two staircases will be conserved. One of both has been partly demolished in the past, which is why this staircase does not reach the ground floor any more. The choice is made to reconstruct this part of the staircase, so that the historic situation is restored. Going back to the past can thus be considered a first strategy that is applied here.

When considering the extension of the building, the designer argues that, because the castle is a strong entity, the new part should be a strong entity too. So he decides to separate the extension from the West wing of the castle, and to connect both by means of a small volume. He chooses to clearly distinguish between old and new. At the same time, he selects the same materials for the new building as used in the existing one: brick, glass and lead. His argument here is that the entity should be distinguished by means of the structure, the spatial configuration, the articulation of the façade and the windows. Two strategies can be found here: (1) distinguishing new parts from the old; and (2) tuning new elements to characteristics of the existing building.

Interestingly, the opposite strategy can be found for the redesign of the back entrance. Here the architect chooses to clearly show that a new element is inserted in the old structure, adapting the old building as it were to characteristics of the new extension.

A final strategy can be found when the architect is thinking of a new function for the attic, which he considers a beautiful space. Judging from the analysis of its spatial and functional aspects, none of the functions in the program brief seems to fit well in this space. Therefore the architect prefers to leave the space empty for future use (that does fit well) rather than destroy it by forcing a function into it.

4. THE FUNCTION-BEHAVIOUR-STRUCTURE MODEL

After the quantitative analysis, the protocol was divided again, but now into much smaller segments. Each of these segments contains a separate chunk of information, clearly different from the preceding and the succeeding segments. These segments were coded according to different models found in literature. First a model and coding scheme developed by Akin and Lin was used to analyse the architect's activities during the session (Akin and Lin, 1996; Lindekens, Heylighen and Neuckermans, 2003). The present study wants to deepen the previous investigation by looking at the kinds of activities performed. Therefore we used a model of designing proposed by Gero (1990) and a coding scheme developed by Purcell et al. (1996).

This section will describe the model on which this analysis is based, followed in the next sections by a description of the coding scheme and the results of the analysis. In later studies other models will be tested using the same protocol data. Each model results in a specific coding scheme exemplifying different kinds of information. Comparison between the different models should allow selecting the most suitable coding scheme for analysing the two remaining protocols.

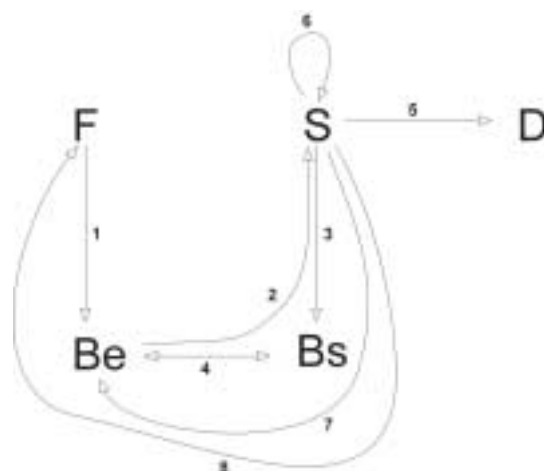


Figure 4. Function Behaviour Structure framework (Gero 2002)

(F = function; S = structure; Be = expected behaviour; Bs = behaviour derived from structure; D = design description; → = transformation; ↔ = comparison)

Gero's model assumes the existence of three classes of variables for designing, which are transformed into one another: function, behaviour and structure (1990, 2002). According to the author, 'the purpose of designing is to transform function, F (...), into a design description, D , in such a way that the artefact being described is capable of producing those functions' (1990). There is no direct transformation between F and D , or between F and S . A first transformation, called *formulation* or *specification* transforms function into behaviours B_e that are expected to enable this function (1). The behaviour of the structure B_s is directly derivable from the structure. This process is called *analysis* (3). Comparing the expected behaviour with the behaviour of the structure to see whether the design meets the needs is called *evaluation* (4). *Synthesis* (2) transforms the expected behaviour into a structure based on knowledge of the behaviours it produces. When structures are synthesized, they can produce their own behaviours and this occasionally may lead to the *reformulation* of the structure (6), the expected behaviour (7) or the function (8). *Documentation* (5) finally transforms the structure into a design description.

5. CODING SCHEME

Based on this model, Purcell et al. developed a coding scheme using three broad classifications (1996).

5.1. Level of abstraction

The first classification addresses the complexity of the problem domain and characterises each protocol segment as belonging to one of three different levels. The interpretation of these levels has been adapted slightly in response to the specificity of this experiment and design assignment.

- The *system level* (0) applies to general aspects about the whole building. Large entities (e.g. 'extension', 'inner court', etc.) are also considered belonging to this level.
- The *subsystem level* (1) covers individual spaces or volumes, independently of the totality of the building.
- The *component level* (2) applies to aspects related to building elements (physical components such as floor, roof, staircase, connection, garden, etc.) and characteristics of these components (e.g. colour, material, texture, ...).

5.2. Function-Behaviour-Structure

The second classification concerns the form of reasoning used throughout the design episode:

- *Structure S* indicates manipulation of physical properties in order to generate a physical solution to an abstract problem (e.g. volume, material, shape, size, elements, ...).
- *Behaviour B* applies to reasoning about how an object behaves or acts in given circumstances (e.g. connecting, relating, providing light, ...).
- *Function F* refers to the manner in which the designed object fulfils its purpose (e.g. program, protection, light, heat, sun, shadow, noise, view, ...).

5.3. Strategy

The third classification characterizes the designer's activity (problem-independent event analysis of the data) and applies the different transformation processes as described in the model to the protocol. Each strategy is divided into four sub-classes.

- *Analysis of the problem* (A_p – analysing the problem; C_p – consulting information about the problem; E_p – evaluating the problem; P_p – postponing the analysis of the problem)
- *Synthesizing a solution* (P_s – proposing a solution; Cl – clarifying a solution; Re – retracting a previous design decision; Dd – making a design decision; Co – consulting external information for ideas; Pd – postponing a design action; La – looking ahead; Lb – looking back)

- *Evaluating a solution* (Ju – justifying a proposed solution; An – analysing a proposed solution; Pa – postponing an analysis action; Ca – performing calculations to analyse a proposed solution; Ev – evaluating a proposed solution)
- *Explicit strategies* (Ka - explicitly referring to application knowledge; Kd – explicitly referring to domain knowledge; Ds – explicitly referring to design strategy; X – all comments made by the experimenter).

This coding scheme was applied to our protocol data, the results of which are described in the next section.

6. RESULTS

6.1. GENERAL OVERVIEW OF THE CODED PROTOCOL

Figures 5 and 6 graphically represent the 27 categories of the coding scheme. For reasons of clarity, the design session is divided into two parts. The first part, capturing about 50 minutes of the session, is shown in Figure 5. The second part capturing the rest of the session is represented by Figure 6. In these figures the vertical position of each line indicates the category a certain event belongs to. The horizontal position indicates time, while the length of an event is represented by the length of the horizontal lines. The breaks that pop up randomly occur for various reasons.

Firstly, in some parts in the protocol the designer refers to what he must do specifically for this experiment. Since he is not thinking about the design in these cases, no codes could be assigned to these segments. As we have seen in the qualitative analysis, particularly in the first ten minutes of the session the designer is discussing how he should proceed for the experiment, which explains the gaps in Figure 5.

A second reason for the discontinued lines is the fact that the designer sometimes stopped talking understandably. Here no transcription of his utterances could be made and thus no codes were assigned.

A final reason is the fact that whenever the designer refers to an explicit strategy, he is not thinking about the problem domain, so no codes were assigned for the problem domain categories.

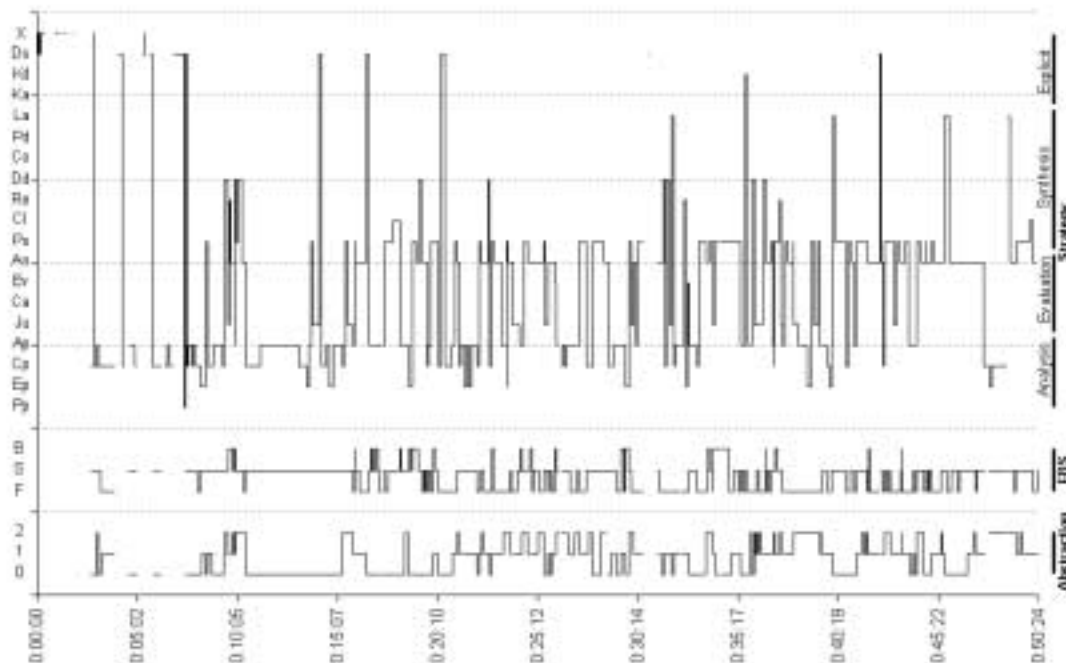


Figure 5. Graphical representation of the first 50 min of the design session.

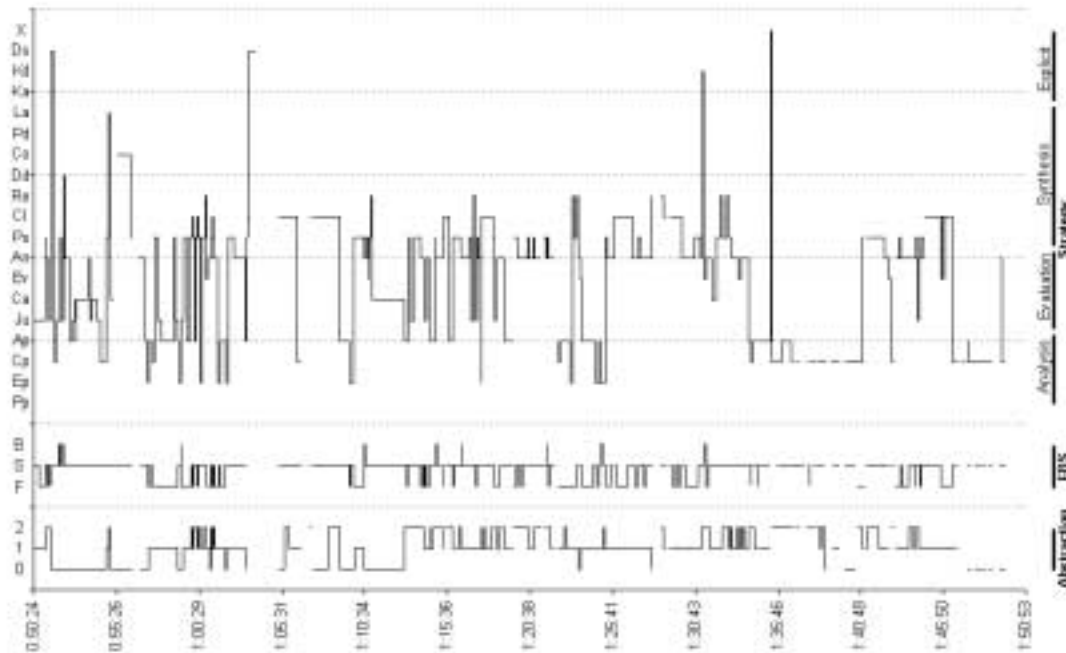


Figure 6. Graphical representation of the second 50 min of the design session.

Having coded the segments, we have information about the designer's activity at each moment during the protocol. The bottom line in each Figure represents the level of abstraction the subject is working on. The middle line indicates whether the designer is thinking about function, structure or behaviour. The top line shows which strategy is used to advance the project.

One can notice a rapid change between the different activities during the entire design session. Combining the three classes in one graph allows comparing the information from all three categories.

Our first findings are very similar to what Purcell et al. found in their analysis of a product designer designing a bike rack. The main difference seems to concern the amount of reasoning about function and behaviour. In our protocol, almost no reasoning about behaviour occurs, whereas in Purcell's protocol reasoning about behaviour was one of the main activities. Similarly, reasoning about function is a main activity in this protocol and is almost missing in Purcell's analysis.

6.2. SPECIFIC ANALYSES

6.2.1. LEVEL OF ABSTRACTION

When examining the bottom line in Figures 5 and 6 we can divide the protocol in four large sections. Figure 5 shows that during the first 20 minutes, the architect is mainly thinking on the system level. This means that he makes decisions about the totality of the building first. Subsequently he is thinking for about 30 minutes on the three levels of abstraction simultaneously, although there is a tendency towards the subsystem and component level. In Figure 6 we have a similar pattern. During the first 20 minutes the architect thinks mainly on the system level. When looking back at our qualitative analysis (section 3), we can see that during this period the architect is summarizing and reviewing his previous decisions. It seems that after this 'review', the decisions about the totality of the building are fixed because in the last 35 minutes hardly any reasoning on the system level occurs. The focus completely shifts towards the sub-system and component level here. We did not use a special level for detailing in this analysis, since the designer did not have the time to develop his design into detail. In later analyses, however, the detail level may be a fourth useful level to consider.

6.2.2. FUNCTION – STRUCTURE – BEHAVIOUR

Figures 7 and 8 display the amount of reasoning about function, structure and behaviour, calculated over intervals of respectively two and a half, and ten minutes. The fine grain in Figure 7 reveals a rapid succession of 'peaks', indicating cyclic changes between each of the three activities, which corresponds with the pattern found by Purcell et al. (1996). Conceptual reasoning, which in their definition involves reasoning about function and behaviour, continues until the very end of this session, be it less than in the first part of the session. According to Purcell, the end should contain 100% of reasoning about structure. The difference here can be explained by the fact that the architect had to stop the design after two hours. At the end of the session, he was looking for examples to detail the design, which indicates that he was not finished yet. The start of the session should contain 100% of reasoning about function and behaviour. This is not the case in this protocol either, since the analysis of the existing building induces reasoning about structure right from the beginning of the design session.

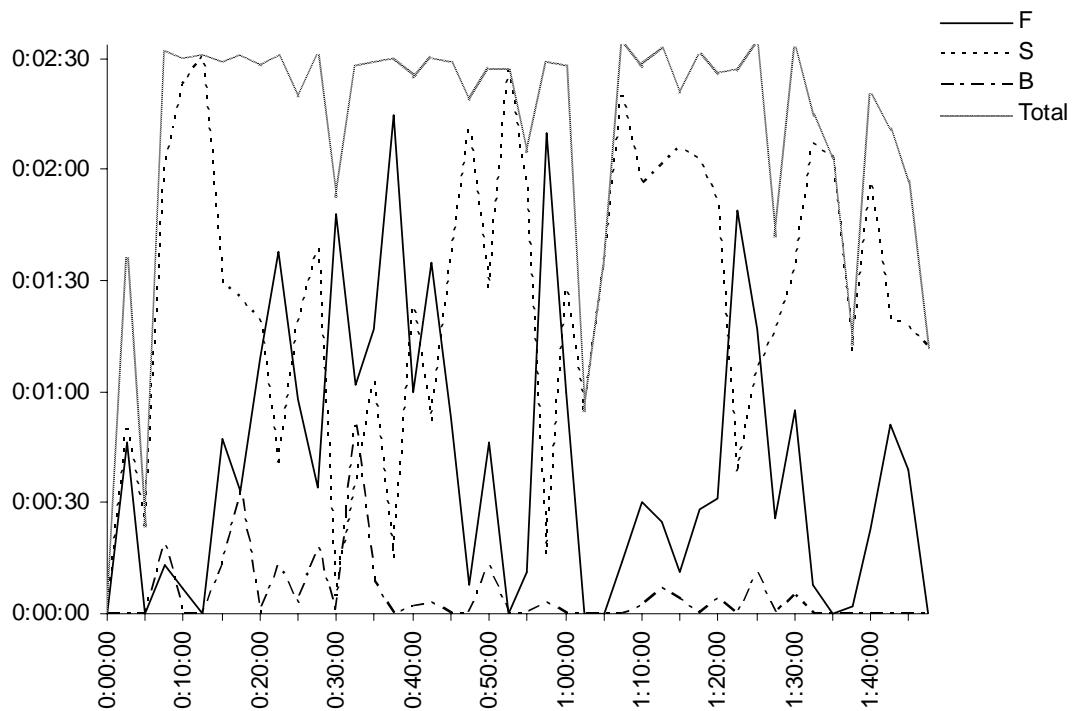


Figure 7. Amount of reasoning about function, structure and behaviour, calculated for a 2,5 minute interval.

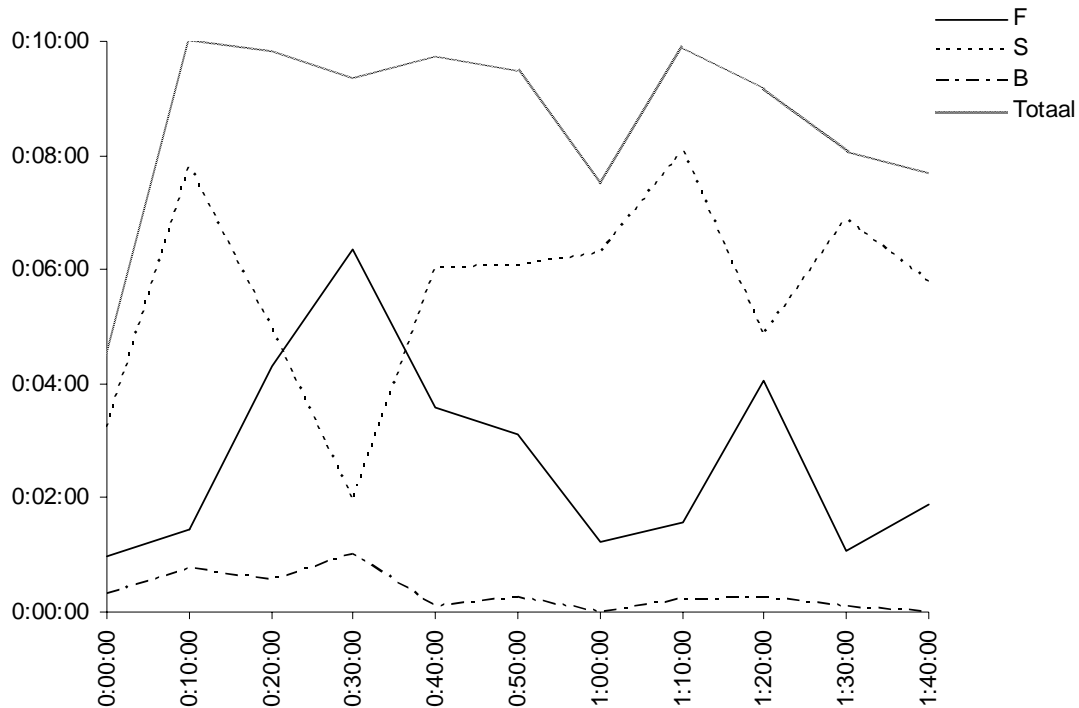


Figure 8. Amount of reasoning about function, structure and behaviour, calculated for a 10 minute interval.

Figure 8 plots a more general pattern in the protocol, which shows that *structure* clearly dominates most of the session. Although *function* is dominant in part of the beginning of the session, *structure* is more important overall and certainly towards the end of the session. This again confirms the findings of Purcell et al. saying that a 'design generally proceeds from a conceptual description of a problem (which involves reasoning about function and behaviour) to a description of an artefact as a solution to the problem (this involves reasoning about structure)' (1996:243).

The architect first makes several attempts to place elements of the program in different parts of the existing building and the extension. Only when he has found an organisation that fully pleases him, he starts thinking more profoundly about structural aspects. Even though he still questions his organisation from time to time, the main focus is now the structure. According to the qualitative analysis reasoning about the program returns most often in the design session. Here the quantitative analysis shows that even if this is the case, reasoning about the program often involves structural thinking (surfaces, locations,...) and not only functional thinking. This also explains the first peak of structural reasoning in the beginning of the session. The architect says that he prefers to start with calculating m², so even if he is dealing with the program he is reasoning on a structural level.

6.2.3. STRATEGY

Like for structure, function and behaviour, separate graphs for strategy were made as well. Figures 9 and 10 show the protocol data divided into the four subcategories of strategy: analysis, synthesis, evaluation and explicit strategy. For each of them one line is plotted over time.

In terms of strategy we see a similar pattern as for function, structure and behaviour. The graph in Figure 9 is even denser, which means that switching between the three main categories analysis, synthesis and evaluation occurs at a higher rate than between function and structure.

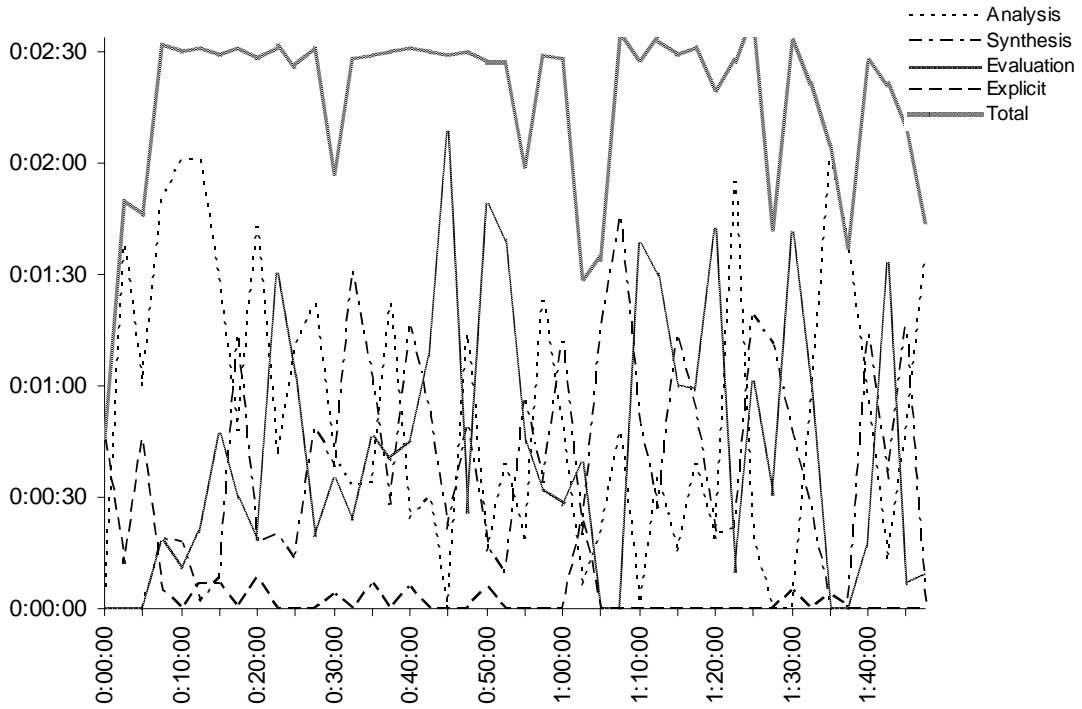


Figure 9. Amount of analysis, synthesis, evaluation and explicit strategies, calculated for a 2,5 minute interval.

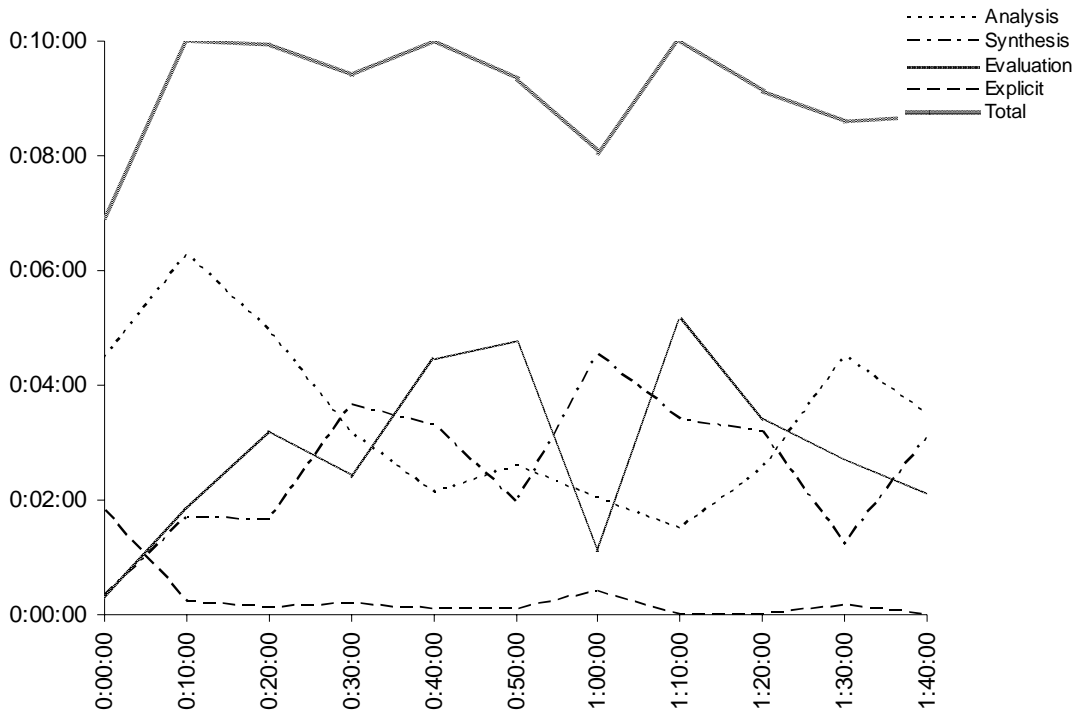


Figure 10. Amount of analysis, synthesis, evaluation and explicit strategies, calculated for a 10 minute interval.

Peaks of analysis and synthesis occur at short intervals, and during the whole session. Peaks of evaluation are less frequent and separated by longer intervals.

Figure 10 shows that the first 30 minutes of the session are dominated by analysis. Here the architect is analysing the program of the building and the existing building parts. In the middle

part of the protocol evaluation and synthesis dominate the session, whereas at the end of the session analysis takes over again. At first sight, this seems quite surprising. Logically the main analysis occurs at the beginning of the session, and although analysis is never completely absent during design, a peak at the end of the session is not what one would expect. This peak may be explained by the fact that the designer is reminded that only 15 minutes are left. The primary aim of this experiment was to test the use of DYNAMO during the design, and the designer starts using this tool at this moment. He searches a case base of existing reuse projects and tries to find elements that are relevant to his design.

Explicit strategies are mainly apparent at the beginning of the protocol, and they reappear with longer intervals later on in the design session. It is clear that the architect first organizes 'his task' before he actually starts working on it. He tries to get grip on the assignment and examines how he should cope with the different tasks. Once this strategy is set, he only sporadically thinks about how to continue the design.

7. DISCUSSION

Although we cannot draw general conclusions based on a single design session, we have found in this protocol a number of remarkable aspects, which are worth investigating in later studies.

Four main foci of attention (program, location, materials, volume) showed up during the session, supplemented with some minor sideways (history, economy, bearing structure). Since these were all common aspects of building design, there are at this point no grounds to claim that redesign requires other foci of attention than new design.

Different design strategies are used for dealing with the reuse aspects. The strategies mentioned here are definitely not exhaustive and more research is needed to investigate what other strategies are commonly used by practitioners and for what reasons.

We have seen that the designer uses more explicit strategies in the beginning of the session. It seems that he is organizing the design task at this time, yet without mentioning explicitly a specific analysis of the building.

The main difference we have found between our protocol and the results from literature was the absence of reasoning about behaviour in favour of reasoning about function. It is not clear yet whether this has anything to do with the fact that this protocol considers redesign, or with more general differences between product design and architecture. One hypothesis, however, is that since the behaviour of the existing building is known, and is not questioned by the architect, it does almost not appear in the protocol.

The most remarkable result in this study was the apparent importance of the analysis of the existing building as an input of information. First of all, we have seen that the amount of analysis is higher in the first part of the session. Although we would expect mainly conceptual reasoning at this point, quite a lot of structural reasoning occurred already. This may be due to the reuse aspects of the analysis. The protocol shows that right from the start some very specific structural decisions were taken, which would have been much more unlikely in new design. Secondly, it seems that reasoning about aspects of the existing building induces and steers new design decisions. This happens during the whole session, and thus appears to be independent from the different phases in the design.

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