Re-Using Re-Design Knowledge
Towards tool support for tacit knowledge exchange

Jonas Lindekens and Ann Heylighen¹
Vrije Universiteit Brussel, Belgium
¹Katholieke Universiteit Leuven, Belgium

Keywords: Design Process, Design Method, Design Strategy, Re-Design, Design Tool

Abstract: Addressing the issue of building re-use, this paper reports on the development of a re-design tool, which aims at helping students and novices (and even experienced architects) in understanding design decisions that have steered existing re-design projects. Furthermore the tool tries to support designers in using this understanding in their own design projects. The paper starts by situating the re-design tool within the overall research setup, and continues by motivating the observations that have led to developing this tool. The core of the paper describes the re-design tool itself and illustrates it with a concrete example. Finally, the tool is framed within the wider context of (architectural) design research, so as to explore where the tool accords or collides with generally accepted design theories.

1. INTRODUCTION

The aim of this research is to create a more profound understanding of re-design, i.e. the process of designing a project to re-use an existing building, and to make these insights accessible to design practice and education. By way of preparation, a literature study on design methods and the design process provided the knowledge needed to set up experiments and observe architects involved in re-design, using both protocol analysis and participatory observation. These preparatory studies unmasked re-design processes as extremely rich sources of (tacit) knowledge. Re-design processes do not only contain procedural knowledge on how to tackle a re-design problem, but also a considerable amount of content knowledge. They illustrate what values architects attach to aspects of the existing building, and
show what qualities are connected to functional, spatial, formal or conceptual design ideas. Given the key role of tacit knowledge in re-design, an attempt is made to capture the knowledge involved in concrete re-design cases and make it available through comparison across cases and/or confrontation between various interpretations. To this end, cases are represented analytically by means of a computer tool that makes diverse aspects and fragments of the design searchable and comparable. This should result in an extendable matrix of re-design strategies to support student and professional architects involved in re-design. In a final stage of this research, a working prototype of the tool will be used and evaluated in an educational context. Based on the observations and the evaluation of this tryout, the tool can be further optimized.

2. **MOTIVATION**

In architectural practice and education, concrete examples play a key role in the development of new design ideas. Many books and magazines report on contemporary practice by publishing texts, pictures and drawings of actual design projects. Leading designers lecturing about their work or architecture critics reviewing contemporary practices are common ground in many countries. Many architecture institutions make yearly architecture trips and visit exemplary projects in order for students to learn from them.

In view of this, concrete architecture projects can be said to act as a well-developed communication medium among architects. By communicating about their projects, architects exchange knowledge with their colleagues. Obviously, a necessary condition for this knowledge exchange to be successful is that the information given can be easily understood. Although seasoned professionals might have little problems with this, questions arise as to how students and novices digest this information.

During exercises with 2nd year architecture students, we noticed that many have difficulty to profoundly understand a building when looking at plans, sketches or pictures. Characteristics that are obvious for an experienced architect are not necessarily so for them. Sometimes they even completely misunderstand certain qualities of a building because they cannot place them in a wider context. Moreover, students cannot easily distinguish important from unimportant elements. Only when they actively and very explicitly analyze a building, they really start understanding it. In addition, we noticed that close guidance during this analysis is needed to help students focus on essential aspects and, even more important, to help them broaden the scope of their analysis.
One may assume that experienced architects implicitly analyze the available information of a project. They can interpret the project data, consider the qualities and problems of the project, and postulate alternatives or improvements. Students, on the other hand, have only a limited capability to do so: for them interpreting the information given, and knowing what part of the information is relevant and why is difficult. One of the reasons seems to be that students lack the necessary background to swiftly interpret project information. For experienced architects, a concrete project shares knowledge not so much through transferring large amounts of information, as through catalyzing understanding.¹ It invites them to see analogies from their own backgrounds, contexts, and fields of expertise. This input is what distinguishes experts from novices. For the latter, the lack of experience and expertise considerably limits the communicative power of cases.

We can help students interpret a project by explaining it in much more detail than is usually done for an experienced audience. While this may improve their understanding of the project, they will still have difficulty applying this understanding in their own designs. To this end, the project should be translated into design information that is readily usable by a (novice) designer. Each piece of information should be carefully digested, so that investigating a case becomes ‘active learning’. Architects do not only need the capacity to understand, but also to judge and value situations. Here interpretation plays a key role. For novices interpreting data is not obvious, it is imaginable that ‘bad’ examples are considered ‘good’ and therefore taken as a reference.²

¹ In fact, cases can be said to operate like springboard stories. The communicative power of storytelling comes not only from the story itself, but from the reaction that it elicits in the listener (Denning, 2001). Similarly, the design knowledge communicated by cases is not (only) in the project itself, but in the meaning architects create out of it, linked to their own context. Thus, for experienced architects, cases are less a vehicle for communicating large amounts of knowledge and more a trigger of new connections and patterns in their existing information, attitudes and perceptions. Cases help rearrange the huge amount of tacit knowledge already with the architects so that they can understand the connection between things in a different sense. Moreover, cases, because they are generated by architects, will fit perfectly other architects’ own contexts, environment and problems. The vocabulary in which they are expressed is completely friendly and natural to them, since it is they who created them.

² In a series of interviews with design teachers, one teacher explicitly complains about students’ lack of criticism (Heylighen and Neuckermans, 2002). According to him, many students tend to adopt forms, shapes or materials from other projects, and there is nothing wrong with that, provided they know why they choose a specific example and draw the full consequences of their choice. What is very difficult for students, he assumes, is to separate the sheep from the goats: “I don’t blame them for adopting things, but for adopting them without question, without reflection.”
Architects and other designers mainly think in a visual way (Cross, 1982). Verbal descriptions of how a project evolved may act as a threshold since they are hard to translate into design knowledge ready-to-use by novices. Therefore it is important to provide as much information as possible in a graphical way. Since verbal information can be important in the formation of concepts too (Lawson and Loke, 1997), text will be used as a secondary source of information. The following section will outline how these considerations are translated into a concrete re-design tool.

3. DESCRIPTION OF THE RE-DESIGN TOOL

The re-design tool is conceived as a case base, where each case contains detailed information on a re-designed building or structure and the re-design process behind it. In addition, main strategies occurring in multiple cases are generalized and collected separately. This collection can be represented as an extendable matrix to provide a clear overview of possible re-design strategies. The tool’s interface allows for browsing, searching, comparing and adding new data.

![Figure 1. Scheme concept tool](image)
3.1 Contents of the case base

Our goal is not only to collect raw project data, but also to try and reveal the process from disused to re-used building. Moreover, we want to show why the architect made certain choices and decisions, and what qualities and shortcomings the resulting design shows. Therefore we divide the design process into separate lines of thought, showing the problems and opportunities of the existing building, its limitations, qualities and shortcomings, and the motives underlying the solution. The different aspects considered in the design process are untwined and treated separately, as if the designer explains in detail each of the considerations made.

Every line of thought can comprise different sorts of information (drawings, sketches, notes, pictures, diagrams, texts). In order to represent them in a coherent way, these fragments of information are labelled according to the following types:

- analysis: information on the existing building and building context (features, qualities, problems)
- interpretation: the designer’s interpretation and value judgment of this information
- synthesis: information on subsequent design actions (alternatives, choices, decisions, possibilities).

Apart from fragments of information on the building and its design, the relation between these different fragments and the overall logic applied in the line of thought are described separately. Users can explore each individual design decision and discover what consequences the combination of problem, interpretation and decision has for the resulting project. Furthermore they can explore how these separate lines of thought interact.

As mentioned above, visual information accords best with architects’ way of thinking. In addition, information should be directly understandable for students and novices. This means that raw project data (pictures, drawings, plans) cannot be used as such, as they contain too much information that may bias the focus of attention. Reduction processes can help eliminate all abundant information from these data sources. Leupen et al. (1995) distinguish between four mechanisms to graphically elucidate specific information: morphological reduction, typological reduction, addition and disassembly. Each of them can be further subdivided according to the type of information to be elucidated. The re-design tool uses these processes to represent and clarify re-design cases. A detailed description would transcend the scope of this paper, yet some of them are illustrated in Section 4 and further elaborated in (Lindekens, 2004).
3.2 Classification

Having stored re-design projects as lines of thoughts, how do we locate the right one at the right time? How to supply relevant lines of thought to a (student) architect interested in a specific aspect? Indeed, we do not merely want to provide users with access to large archives of lines of thoughts, but with just those that are relevant to their design task or topic of interest. The standard way for a case base to address this issue is by indexing, i.e. by labelling cases with a small set of indices that can be compared with features of the probe. Since our tool is developed precisely to reveal and map the multiplicity and interconnection of aspects involved in re-design, probably more than one label will be needed to index a single line of thought. At this point, we propose a classification that allows characterizing, retrieving, and comparing lines of thought along four dimensions: dimension, scale, level of abstraction, and chronology.

The subject or dimension of a line of thought distinguishes between historical, functional, structural, economic, and other aspects. The totality of aspects considered shows the architect’s fields of interest for a specific project. This set can be richer or narrower depending on the project and on the designer’s individual preferences. Also the level of experience plays here: very often novices know only a limited number of approaches to develop their concepts. Table 1 gives a non-exhaustive overview of possible dimensions.

![Table 1. List of dimensions](#)

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Historic</td>
<td>Conservation; building evolution; previous uses;</td>
</tr>
<tr>
<td>Technical</td>
<td>Stability; installations; construction details; acoustics;</td>
</tr>
<tr>
<td>Functional</td>
<td>Organization; program;</td>
</tr>
<tr>
<td>Urban</td>
<td>Volumes; context; landscape; gardens;</td>
</tr>
<tr>
<td>Ecologic</td>
<td>Use of materials; energy management; waste treatment;</td>
</tr>
<tr>
<td>Economic</td>
<td>Building costs; time management; running costs;</td>
</tr>
<tr>
<td>Documentary</td>
<td>Industrial archaeology; conservation;</td>
</tr>
<tr>
<td>Spatial</td>
<td>Spatial qualities; connections; views; relationships;</td>
</tr>
<tr>
<td>Architectural</td>
<td>Formal articulation; tactile experience; meaning;</td>
</tr>
</tbody>
</table>

3 In everyday life, we use a similar technique to look up something in a book. Yet while we call ‘an index’ the entire lists of keywords in a book, case bases use the term for each single keyword assigned to a case. To eliminate potential confusion, a distinction is made between probe and label indices: the former refers to the description we use to find something in the case base – the reader’s guess at a good keyword; the latter to the description that has been assigned to the contents of the case base – the alphabetized list of keywords in a book (Domeshek, 1994).
A second dimension concerns the extent of the decision, its scale. Some considerations influence the complete building and even its surroundings; they act on an ‘urban scale’. Others deal with only one volume or space, or with a specific building part or detail of the construction. In general, four different scales can be distinguished: urban scale, scale of the building volume or space, scale of the building element, and scale of the detail (Neuckermans, 1992). This should permit users to look at large-scale decisions first and zoom in on details later or vice versa.

A third dimension considers the level of abstraction of a line of thought. Some considerations deal with very concrete physical actions, e.g. placing a wall or removing a staircase, others are much more conceptual, e.g. creating a unity or adding identity. Very often abstract concepts are proposed first and are translated into physical actions later on. By distinguishing the level of abstraction, related statements can be compared.

A last dimension concerns the chronology in which certain lines of thought are developed. This is only applicable to projects where the design process has been adequately recorded. When a project is analyzed post-hoc, no such information can be retrieved.

3.3 Strategies

Besides separate lines of thought, we have mentioned, re-design processes involve overall or specific re-design strategies, certain attitudes towards the design, influencing – or even steering – design actions that modify the existing building. Depending on the dimension(s) considered, different strategies can occur, possibly acting across different scales and/or different levels of abstraction.

The case base contains detailed descriptions of specific strategies used in a project. This should enable users to browse projects or separate lines of thought so as to understand the exact meaning of a strategy in a specific context. Ultimately, however, these strategies are meant for re-use in new re-design situations. Therefore, users should consider the generalizable and essential content of the strategy, a skill acquired through experience.

In order to help novices practice this skill, re-design strategies are generalized across multiple projects. Summarizing these generalizations in a matrix creates a provocative and interactive re-design guide for new projects (Figure 2). By organising this summary according to the four dimensions, users can focus on just those strategies they consider most relevant. In the matrix, the vertical axis enumerates the generalized strategies; the horizontal axis can represent the dimension, scale or level of abstraction; the dark parts represent combinations of strategy and dimension already available in the
case base; the light parts highlight combinations to be explored in new re-designs.

Figure 2. Matrix of re-design strategies

3.4 Recording of cases

The most complete way to collect project data is to let architects record the entire design process from start till end. Obviously, this is extremely time consuming and not evident. Alternatively, researchers can take care of the recording, yet for the architect(s) involved it is still troublesome to undergo. An easier way is to analyze a project afterwards, and ask the architect(s) to explain how the design evolved, or to make assumptions without asking the architect. Although in these situations, users are not sure about the correctness of the information, a possible explanation for a project can be as inspiring as the ‘real’ one, if only because it reveals how re-design projects are perceived and interpreted by third parties.

Incompleteness of the project information is inevitable, yet also unproblematic. The overriding goal of the re-design tool is to give users a flavour of the approaches that exist, a big-picture idea of what steered and influenced the decisions behind concrete projects, and an awareness of the impact on the final result.

4 This bias of information has been described by Cross et al. (1996) concerning the ‘think aloud’ method, while Lawson (1994) discusses the shadiness of post hoc interviews.
3.5 Use and action

The re-design tool has several possible uses, each of which influence learning and understanding in a different way.

Users can randomly browse through the case base or explicitly search for a specific project. Once a project has been selected, the information about all lines of thought is displayed. Alternatively, users can look for how a specific dimension is addressed in a project. In this case only the relevant line will be shown, yet they can still decide to view all project information. By viewing all lines of thought, users can explore the different aspects of a design and the ways in which it was conceived, analyzed, interpreted. Besides the dimensions addressed by the design, they can distinguish essential from secondary issues. Besides the scales covered by the design, they can detect at which scale most design decisions were taken. The same applies to the level of abstraction: is the design conceived on an abstract level, or did most lines of thought involve concrete considerations? Finally, users can find out which considerations came first and which were added only at the final stage of the design.

Exploring a single case is not always satisfactory. Sometimes it is desirable to compare multiple cases so as to fully understand the differences between them. In the re-design tool, users can compare the entire set of lines of thought across multiple projects. This may reveal different projects being supported by similar aspects, or similar results being based on different aspects. In addition, users can compare in detail the contents of specific aspects. They can try and recognize similar reasoning in different projects, and finally apply this in their own projects, thus learning generalized ways to look at and think of a re-design problem.

Browsing cases is the simplest way of use. Design knowledge and understanding, however, are not so much developed through observation as through practice. Indeed, actively designing projects is the generally accepted way of learning design, yet it is not always beatific. While students often obtain good results for their projects, they have difficulty explaining why they made certain choices. This suggests that they are not completely aware of the qualities and problems of their projects. An interesting student exercise is therefore to analyze an existing design and unravel its (possible) lines of thought. These can be submitted to the case base so as to share the insights with other users. Not only new cases can be added, existing cases can be extended with missing information or fresh interpretations. Obviously, this way of use must be adequately supervised so that only valuable information is added to the case base.

A fourth way of use occurs when approaches explored in one case are applied in the context of another case. When a user discovers say an
illuminative organization diagram in one project, s/he may want to develop a similar diagram in another project. This results in directly comparable information for other users, while the provider of this information learns new ways to analyze certain aspects of a re-design project not considered before.

4. A CONCRETE EXAMPLE

By way of example, this section describes a concrete line of thought. The example is taken from an experiment in which part of an architect’s design process was recorded. Within two hours he developed a concept for the extension of an architecture school based in a historic building (Figure 3). During this design process, one of the architect’s considerations is the identity of the existing building. He remarks that the building has a clear identity, composed by different wings and elements. This makes him decide to also give the extension a clear identity of its own; it should have autonomy rather than be an annex, and definitely not become one with the existing building. Later on, he says that contrasts are unnecessary; he selects materials that conform those of the existing building: brick, glass and lead. A clear identity, he continues, can be established by the architectural elaboration: using a special structure, recognizable inside as well as outside; choosing a function that requires an open space. The strategy used here can be summarized as juxtaposing new and existing as two separate identities. To label the line of thought, we chose ‘identity’ as dimension. A more general label, e.g. ‘concept’, would comprise too many lines of thought, while a more specific one, say ‘identity composed of different historic parts’, would be applicable to one line of thought only. In terms of scale, this line of thought obviously fits the scale of the building. Regarding the level of abstraction, the first drawings can be named abstract and the last ones concrete, but an exact classification has not been made yet. Since this fragment was taken from a protocol analysis, we have exact time information and thus can label each drawing with its time stamp in order to establish the chronology of the design process.

5. SITUATING THE TOOL IN A WIDER CONTEXT

5.1 CAAD and CBD

Although not an explicit objective of the research, the approach proposed somehow fits under the heading computer-aided architectural design (CAAD). The same analytical approach could indeed be developed in a
paper version having the same benefits for students as the computer tool. It would be much harder, however, to make this knowledge available to a wider audience. Moreover, computers offer powerful search capabilities, which facilitates finding relevant cases or comparing similar ones. These considerations made us choose the computer as medium.

Figure 3. Line of thought
Within the field of CAAD, the re-design tool can be considered a *case-based design* (CBD) tool to some extent. The main part of CBD systems consists of a case base: a relevant set of specific cases stored as complete records of concrete design experiences. Given a new design task, the system retrieves the most relevant case in memory, after which the corresponding solution can be adapted to the current situation. Similarly, the re-design tool calls upon a collection of re-design cases to improve new re-design projects. At the same time, however, we deliberately break the CBD rules. Whereas CBD systems typically (or ideally) store cases ‘as such’, i.e. as raw and unprocessed as possible, our tool analyzes re-design information in a detailed way to make it easily accessible for students and novices. The use of categories allows to examine specific aspects of a design in isolation without having to study the whole building, as is mostly the case in CBD tools.

5.2 Complexity of the design process

At first sight, the re-design tool seems to adopt a reductionist view in that it reduces architectural design to a sum of different lines of thought considering specific design aspects. Similarly, it reduces the design process to a set of separate actions and considerations. We do not doubt, however, that architects’ design process is highly complex and intrinsically indecomposable (Rechtin, 1991). We believe that architectural design cannot be completely captured by an analytical tool without impoverishing or flattening its richness to some extent. Experienced architects deal with multiple aspects of a design simultaneously. The unnatural division of these aspects into separate lines of thought only serves to illustrate the many design considerations in a clear way for novices. Nevertheless the approach proposed may help students and novices deal with the high complexity of architectural re-design, and broaden their horizon by confronting them with approaches and strategies they might not be aware of. In this regard, it is important for them to know the limits of the tool so that eventually they can transcend them.

Researchers have tried to capture this complex process in various models, several of which include the sequence *analysis-synthesis-evaluation* (Lawson, 1980; Neuckermans, 1975). This very coarse model of how designers think evolves in recurring loops throughout the design process. Since many lines of thought will comprise this sequence, either once or recurrently, the support offered by the re-design tool – consisting of a collection of lines of thought – can be considered in line with this general model of the design process.

---

5 For a comparative study of various CBD tools for architecture, see (Heylighen and Neuckermans, 2001).
5.3 Design methods

A major concern in developing the re-design tool was to avoid being too prescriptive as to how students (or architects) should design. Since design problems may be addressed by different design methods, we did not want to limit this variety. The tool should be a guide, not a prescriptive method. In order to get an idea of the extent to which it respects this variety, let us have a look at some well-known methods.

Broadbent describes four design methods that comprise the major approaches towards generating “three-dimensional forms of buildings, interior spaces, and the spaces about the buildings” (Broadbent, 1988).

The first one, pragmatic design, uses straightforward considerations of basic needs to guide the design. An example is the determination of the surface area required for each room in a building. Although not specific for re-design, our tool does allow and support this kind of reasoning. Novice designers will find examples of surface studies indicating how room surfaces were determined. They will not only find total surfaces, but also ratios between functional space and circulation, or between net and gross surface areas.

A second method, called typologic design (previously iconic design), starts from a known building type. Building types are abstractions of a traditional building form, allowing for interpretation to a certain extent. They can be understood as analytical reductions of a building, something the re-design tool heavily relies upon. When dealing with re-design, one cannot but start from an existing building, and thus consider what the building was before and what is should become afterwards. In this analysis, the building’s typology is very likely to pop up, as certain lines of thought will probably consider the type of the building or building elements.

A third design method is analogic design. Analogies can be drawn with phenomena outside or within the domain of architecture. In the first case, the analogy should pop up in at least one line of thought describing the project and, as such, can be inspiring for new projects. The use of within-domain analogies is explicitly supported by the tool, while trying to prevent mere copying of design ideas. The subdivision into lines of thought highlights the essence of an idea instead of purely formal considerations, which should stimulate users to re-interpret ideas rather than copy formal elements.

A last method, called syntactic design (previously canonic design), calls in syntaxes or canons to guide design thinking. Examples include measurement systems, harmonic proportions or grids, on which design decisions are based. When visiting a building, these non-physical elements are sometimes hard to capture; when analyzing a project, they are often straightforward to identify and communicate.
Together these examples indicate that the tool supports multiple design methods without being prescriptive in one way or another. It shows possible directions in which to proceed, but leaves the choice up to the user.

5.4 Creativity

The re-design tool aims to stimulate creativity, not hamper it. Creativity involves the easy recombination of ideas in the preconscious (Barron, 1969), and thus requires the skill to easily recombine, but also content to be combined. Being creative presupposes having sufficient baggage to draw from (Neuckermans, 1994). The re-design tool helps users build up or enrich their baggage by widening up a whole range of creative solutions. The downside is that users might become prepossessed by a specific solution and cannot free their thoughts from what they found in the case base. However, recent experiments with student architects suggest that using a case base positively affects the overall quality and creativity of what students design (Heylighen and Verstijnen, 2003). No evidence was found that users of design case bases risk to be hindered in their creativity; quite the contrary seems to be the case.

5.5 Designers

Having discussed how the re-design tool respects different design theories, let us briefly address the different kinds of users. Broadbent distinguishes between two kinds of designers: divergers and convergers. The former come up very easily with a variety of design solutions for a specific problem, but have difficulties in converging to one. The latter find it hard to create a set of solutions, but swiftly converge to one once a set is made. In order to be a good designer, Broadbent states, one needs “some means of transcending personality, of adopting the characteristics of the diverger at certain stages in design, and of the converger at others when this seems more appropriate” (Broadbent, 1988). How can the re-design tool help these two kinds of designers? The divergent qualities of proposing a variety of solutions are obviously supported by the case base element of the tool. Convergers who cannot come up with various solutions themselves, can search the case base for similar problems. This provides them with a range of solutions they can evaluate for their own situation.

The convergent qualities of the tool lie in the explanatory aspect of the individual lines of thought. Divergers who have a range of solutions but cannot choose between them, can find in the case base how other designers solved a similar problem, thus getting information on which solution may be preferred for the problem at hand.
6. CONCLUSION

After motivating our decision to develop a re-design tool, we have described how the proposed tool tries to address as many of these motives as possible, and have illustrated its functioning with a concrete example. Moreover, we have situated our approach in a wider context by confronting the tool with insights from (architectural) design research in general.

The results of this confrontation strongly suggest our approach to be in line with existing design theories and models. The re-design tool does respect the complexity of the design process and is unlikely to hinder creativity; the tool may even stimulate it. Moreover, different kinds of designers all should find valuable support in its use.

Nevertheless, we are aware of the potential traps of our approach. Although the re-design tool allows for different design methods, designers may get blocked when using it. For some, the mere fact that it requires using a computer may act as a considerable threshold (Heylighen and Segers, 2002). Designing does not only involve thinking, but also sketching, looking at pictures, visiting the site, and other activities that are preferably performed without a computer.

It is clear that the tool explicitly focuses on re-design projects. It is also clear that a CBD tool is only as valuable as the contents of its case base. By narrowing the scope of the tool in this phase, we can create a working prototype with a limited amount of cases, which will be tested in an educational context. Possibly, after evaluation of this tool, we may consider extending the tool so as to include other project types, or even better, to open it up to architectural design in general.

ACKNOWLEDGEMENTS

The authors are respectively Research Fellow and Postdoctoral Fellow of the Fund of Scientific Research Flanders.

REFERENCES
