New Design Methods for Computer Aided Architectural Design Methodology Teaching

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Architects and architectural students are exploring new ways of design using Computer Aided Architectural Design software. This exploration is seldom backed up from a design methodological viewpoint. In this paper, a design methodological framework for reflection on innovate design processes by architects that has been used in an educational setting is introduced. The framework leads to highly specific, weak design methods, that clarify the use of the computer in the design process. The framework allows students to grasp new developments, use them in their own design work, and to better reflect on their own position relative to CAAD and architectural design.

1. Introduction

Design is the key competence that we are trying to teach our architecture students. The term 'design' encompasses designing as an activity, as well as the final outcome of that activity. Students not only learn design by doing, by making design projects, but also by reflection on this process. In the design work, students learn how to cope with design problems, how to structure and plan the design process, and how to use highly varied knowledge and competencies such as structural design, urban planning, physical behaviour, building and construction. In the reflective work, students learn about the nature of design, architecture, and design methods.

This paper concerns reflection about design in an educational setting, in particular from a design methodological point of view. We are faced with a slightly paradoxical situation. On the one hand we note that the (classical) study of design methods is unpopular and held in low esteem (by students and teachers alike), whereas on the other hand architects and students of architecture are exploring with great creativity and innovation new ways of designing, especially with Computer Aided Architectural Design (CAAD) systems. This exploration is supplemented by numerous architecture theoretical studies. We feel that these new developments strongly invite methodological reflection, so that students and architects alike can properly position theirs and other people's work processes and structures in perspective.

The goal in our educational setting is threefold: (i) to provide students with an insight how a number of currently notable architects use the computer in their design process; (ii) to provide them with a framework to analyse such architects and use these findings; and (iii) to use these findings to reflects on their use of the computer in the design process.

We have developed a design methodological approach to study architectural design, combined with architecture theoretical and design computational views. These views are comprehensively captured under the headings "ontology," "method," and "CAAD." The resulting framework can be used to analyse the written work of architects and hypothesize design methods that they have been using. Three contemporary architects are analysed in this manner. For each architect a design method is established. These methods are adjusted for use in educational setting under constraints of time, available software, and group-size. Students have to make a design using one of the presented methods. We present the methods, how they are used in education, and show some examples of student work.

2. Design methodology

Design methods have been at the core of attention since the early sixties. Many of the early approaches [1-6] were inspired by the paradigms of systems theory and rational problem solving [7]. Innovative work was done on the systematic description of the design process, structure of design problems, study of designers and their methods, and reflection on the nature of design. Throughout the development of the field, the complexity of design became more and more apparent. In the early eighties there was dissatisfaction when it gradually appeared that design methodology did not live up to its expectations [8]. Design methods were conceived as rigid, inflexible, and with limited application. The research field expanded into design research: a broad range of investigations into the nature of design, design thinking and cognition, organization, management, and other aspects. Much of design research today happens in laboratory-settings [9-12], or takes its research data from everyday practice [13-17]. Design methods did not fall out of the research scope altogether [18,19], and currently there is increasing attention to the distinction between the rational problem solving paradigm and the reflective practice paradigm [13,20,21].

Design methodology, to conclude, has a rich and varied history. The translation of the research findings to concrete methods is not always obvious, in particular not when students have to do this themselves. Furthermore, we note that the methodological reflection on design is not very popular, both with students and architects. From our experiences in architectural design methodology teaching and research (in particular methods developed by Stichting Architecten Research – SAR), we propose that there are five main reasons:

1. Comprehensive and systematic descriptions of design are productive for research purposes to provide a framework, but are too complex and cumbersome to effectively use in practice.
2. The architectural profession and the Building and Construction (B&C) Industry did not undergo major changes, removing the immediate need for design methodological reflection.
3. Design methodologies age and have to be updated so that they tackle the relevant questions of current practice; this updating often did not take place and therefore design methods lost credibility.
4. Architects do not in general view a more transparent representation of the design process by means of methods favourably for fear that their own input will be conceived as trivial.
5. There has been a shift of attention from the design process to the design product; with an increasing emphasis on architecture theoretical positions rather than methodological positions.

At the same time we note that while using CAAD systems, architects and students are exploring new ways of designing with great enthusiasm, albeit seldom with design methodological underpinning. Architects have integrated CAAD in their everyday practice in various degrees. There are now a number of leading offices (not always the large ones) that use CAAD in innovative and creative ways, typically using a wider range of computer tools than the traditional CAAD software (such as animation and morphing software, e.g. Lynn, Franken, NOX, and Kolatan and MacDonald) or mixing it with various media (such as Gehry and Eisenman) [22-25]. New organizational forms of the design office appear, allowing for example round-the-clock design teams world-wide [26] and collaborative design [27,28]. This innovative work invites methodological reflection on the design process.

2.1. Design methodology and CAAD

In our view, the computer now presents an occasion where the disciplines of design research, architectural theory, and CAAD can greatly benefit from each other. The attractiveness of design research lies in the scientific basis, the reproducibility of methods, and the general scope of validity of the findings. Yet there often is a gap between theory and practice, and theoretical findings are hard to apply productively in practice. The attractiveness of architectural theory lies in its closer connection to practice [29-37], which makes its body of knowledge much more accessible to students of architecture. However, architectural theory is often highly personal, ill-supported by objective evidence, and hard to translate to general guidelines. Design computing needs a proper domain foundation for the representational structures [38-40] and techniques [41-44] that are used. Most of the domain knowledge in design computing comes from research and from feedback by software users [45-49]. In order to add structures and concepts used by architects, design computing also needs to draw from architectural theory. Although there are examples of cross-disciplinary work between design computing and architectural theory [50,51]; architectural theory and design methodology [52,53]; design computing and design methodology [54,55]; and architectural theory with design methodology and design computing [56,57] for the most part work in the these disciplines sticks to the set disciplinary boundaries.

Design computing can form a common ground to bring together the three disciplines. We believe that this may lead to the following advantages:

- Shared platform between traditional and new form-making. As the computer can play a role in both traditional (e.g. drawing, scale modelling, and sketching) and new form-making (e.g. generation, CNC-milling, and morphing), it can provide a medium in which to compare both ways of form-making.
- Support of real-time processing of great amounts of data. By decreasing the time in which computational results (e.g. for simulation or calculation) become available, the designer can get faster feedback of aspects of the design. This can facilitate understanding of the design.
- Support and study of design. The computer provides both tools for design support, but design can also be studied through the actual use of tools.

- Update of design methods. The computer allows a setting in which keeping methods up to date (and testing them in a design environment) can be done easier than through manual methods.
- Playful medium for design reflection. The computer provides a medium in which methodology can become much more playful and responsive while still remaining consistent and open for systematic inquiry. In this way, it can meet both the demands of the architect in practice and the design researcher.

2.2. Starting points for the framework

Next to the perspective outlined above, there are a number of additional considerations that influence the current work. These concern the educational setting, the desired scope of the results, and methodological implications of the work.

2.2.1. Educational setting

The course from which we present our findings, was started in 1999, running once a year since. It is taught in an eight-week period, combining theoretical lectures with an exercise. The theory section deals with the design methods of three particular architects. In the exercise section, students have to use one of the methods to make a design. The design task is to design student housing and an art pavilion on the campus site of the university. Students can focus either on the urban level of design (designing the student housing) or on the building level (designing the pavilion). The course was also given in the form of a one-week workshop at the Czech Technical University. The design task was changed to design an addition to the old town hall at the Old Town Square in Prague.

In both cases, the course is aimed for students in their third year of study or beyond. Thus the students have design skills, CAAD skills, and architectural theoretical understanding. In total 19 students throughout the courses and 5 students in the workshop have taken part in the exercises.

2.2.2. Scope of the design methods

We propose to construct design methods of particular architects on the basis of written material about their work. This leaves out the study of design methods based on observation and/or interview. The main reason for this approach lies in the aim to provide students with a working method that allows them to assess architects other than those covered in the teaching. Students usually only have access to written documents for this purpose.

Rather than trying to construct 'strong' design methods that have wide applicability in multiple domains of design (thus having weak implications for the design outcome itself), we aim to construct 'weak' methods that are narrowly focused on a specific architect – and thus have strong implications for the design outcome. We have to emphasise therefore that the results of the analysis have limited applicability to design in general, and that the expected 'life-span' of the design methods will be brief due to changes in style and working method of the architects in question.

2.2.3. Research methodological limitations

The method of only using written materials poses two serious limitations on the scientific scope of the work:

- As there is no occasion to observe a concrete design process, the construction of the design on basis of written documents is highly conjectural.
- The stated facts about design methods in the written documents themselves may not correspond to the actual use or design processes as they actually happened.

With respect to the first objection, we aim to meet some of these limitations through the framework described below. With respect to the second objection, we adopt the 'normative position' in this discussion [58]; that is, we present the working method as the architect feels it should be, rather than as it turns out to be. This is justifiable only because we want to demonstrate how the architectural theoretical position, the use of the computer, and the design process interrelate.

2.3. Elements of the framework: ontology, CAAD, and method

Any well-developed view about design implies a particular stance about which issues are important, which decisions take precedence before others, and how (sub)results should be interpreted. These issues have to be determined from the written documents that we use in this study. We propose to derive the issues by focussing reading of the documents on three themes: "ontology," "CAAD", and "method."

2.3.1. Ontology

Ontology is the set of related concepts that form the architectural theory of the architect in question. The terms that are part of the ontology are those that re-occur regularly in the writing and that are identified by the architect as important elements in his or her thinking about architecture. As a practical test, by means of the concepts in the ontology, it is possible to reason about most of the work by that particular architect.

2.3.2. CAAD

CAAD covers all those text fragments that deal explicitly with the computer. This is not limited to statements about the actual use of the computer, but can cover all aspects: (re)presentation, use, role, meaning, techniques, and so forth. The statements about CAAD form the position of the architect with respect to the computer.

2.3.3. Method

Method covers all text fragments that deal with the design process, the order of decisions that are or have to be taken, the formation of the design team, etc. The collection of these fragments give indications how the process is organized.

2.4. Developing the framework

The development of the framework proceeds through four stages.

2.4.1. Stage 1: Selection of relevant fragments

In the first stage, the sources are examined for relevant text fragments and images. A text fragment is considered relevant when it contains a statement about ontology, CAAD, or method. The fragment is then copied, coded according to source and page number, and added to the collection of statements. An image is considered relevant when it has illustrative value with respect to the statements, if it shows something of the design process, or if it has a schematic quality. The image is then scanned, coded according to source and page number, and added to the collection of images.

By limiting the search on these aspects, the available material can be captured in a relatively short time on the aspects of ontology, CAAD, and design method. After the first round of reading, this results per aspect in a number of text fragments and a collection of images. The material that is not selected is subsequently discarded in the next stages.

2.4.2. Stage 2: Identification of theoretical concepts

In the second stage of the analysis, important theoretical concepts from the architect were identified from the text fragments. These concepts can be identified either by repetitive occurrence in the text fragments or through emphasis by the author. The concepts constitute the ontological aspects. The concepts are related to each other, so that they form a concise summary of the theoretical position of the architect.

2.4.3. Stage 3: Establish chronological order

In the third stage, a chronological order in which the concepts are used in a design process is established. This order shows which general tasks precede others and which concepts are required before other concepts are used. This order, and the design questions that arise by working in this order, is then further described. This stage is arguably the most subject to conjecture by the researcher.

2.4.4. Stage 4: Correlate images with chronological order

In the fourth stage, the images found in the first stage are correlated to the design method, using the ontology identified before. In this way it is possible to point out how the theoretical work of the architect is related to final outcomes of the design projects, and how images evolve through the design process, and what kind of representations are used by the architect.

2.5. The framework in an educational setting

In order to apply the results of the work in an educational setting, we have to take into account a number of constraints:

- Students do not have the same amount of time to work on a design project.
- A design team in practice consists of many participants; students typically have to work on their own.
- The design office of the architect has particular software and specialists to use it; the students have access to software that is offered via the university.

This implies that for each design method, a translation step has to be made to accommodate for limited time, one person using the method, with the available software at hand. In general, this leads to a simplification of the design methods, in particular with respect to the number of steps.

3. Three architects: three design methods

In the current work, we have applied the framework to three architects: Peter Eisenman, Ben van Berkel, and Greg Lynn. Each of these is a leading architect in the field, recognised by peers, critics, and the general audience. They all are currently active architects. They have published books and articles about their work. They are interesting architects to the students, each with a quite individual style, and no obvious interrelationships personally nor in way of working. Because of their different working styles, the three architects do not present the same kind of work in yet another form. To characterise their work briefly – and unfairly – Eisenman is very 2D-graphic oriented, van Berkel more three-dimensional surface-oriented, and Lynn time-dimensional dynamic shape-oriented. This also means that students with CAAD skills varying from basic to advanced can participate in the course. Furthermore, Eisenman's approach is particularly suited for work on an urban level, Lynn's method is very apt for the building level, and van Berkel's method can be applied on both levels. Again, this differentiates the possible approaches for students.

In the following sections, we describe the design methods for each of the architects. Each method consists of a general overview and a stepwise method. For each method, examples from student work are shown.

3.1. Peter Eisenman

Peter Eisenman's working method relies on a simultaneous production of drawings, scale models, and computer models [59]. The technique of superposition is used to combine historical readings of the site into material that forms the basis of a design [60]. In this way, Eisenman is looking for complexity in material related to the history of the site (he regards the site as a 'palimpsest' – an old parchment with traces of previous texts). In a later phase, this already complex superposition gets an additional layer by means of a diagrammatic model: an image that is associated with the project. This image is used to distort the current design by making the design follow lines and directions present in the diagrammatic model. This is done either in two dimensions, on the plan level, or in three dimensions, in a computer model [61].

Eisenman's method progresses through the following stages:

3.1.1. Phase 1: Reading the site

1. Find as much (historical) maps of the site as possible.
2. Categorize the material with keywords about the content.
3. Find relations between objects of the maps and the design brief. *How?*
    - Use the trace technique to find relevant forms in the map material. Note that for Eisenman form has meaning. Which forms have meaning in the sense of the design task?
    - Are there important lines in the site (references to shapes, objects, places)?
    - Remember to use scale, rotate, and move to reinterpret objects relative to each other.

4. Superimpose the maps and selected objects on the site. *How?*
    - Try to read the site not as a Tabula Rasa, but as an area with history, information, and influence on the design. Refer to the Palimpsest metaphor.
    - Try to find connections between the maps/objects and the site.
    - Look for special places that emerge from this superposition.

3.1.2. Phase 2: Deformation strategy

5. Find a diagrammatic model that is relevant for the design. *How?*
    - A diagrammatic model is an image that depicts some kind of structure, organization, or working of forces.
    - A diagrammatic model may not be derived from the discipline of architecture.
6. Study the properties of the diagrammatic model. *How?*
    - Superimpose the diagrammatic model on the design.
    - Find an interpretation of the structure that you can use for deforming the current design.

7. Translate the properties to deformations of the design. *How?*
   - Use for example densities in the diagrammatic model for contracting or expanding the design.
   - Change the geometry of the model along for example the lines of the diagrammatic model.

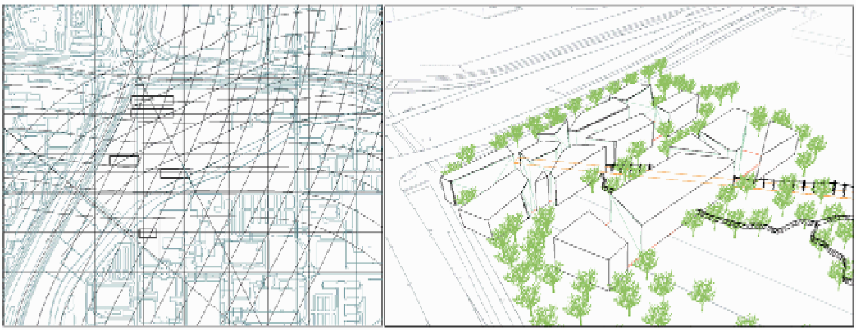
3.1.3. Phase 3: Reflections about the design

8. Eisenman's method is very analytical and needs a lot of referential material.
9. Argue how the superimpositions influence form and location of objects on the site.
10. Argue how the deformation strategy influences the design.

3.1.4. Example of student work

The student took cartographic information about the site and superimposed these on each other, using various transformation techniques. As a diagrammatic image, the student used the ripple-effect of a drop of water, referring to the small river that goes through the campus.

▼ Figure 1: Example of student work using Eisenman's design method.



3.2. Ben van Berkel

Ben van Berkel aims to unite the public-private sphere in the relationship urban environment-building space through the use of continuous surfaces that smoothly combine these spheres [62]. In particular he is interested how this can be achieved through the organisational principles of movement and the circulation system. Van Berkel uses rather traditional analyses to look at the design brief, and aims to derive meaningful diagrams from these that inform the organisation of the design. In order to avoid early design fixation, the notion of an additional 'diagram' is used – a diagram that denotes a special characteristic of the design without being used in a literal sense.

Van Berkel's method progresses as follows:

3.2.1. Phase 1: Movement analysis

1. Make many analyses of current and future movements on the site.
2. Do not draw one line for a particular movement, but use multiple lines to determine densities of movement. *How?*
   - Use for example splines and vary the weights in the control-points.
   - Use the computer as a sketching device.
   - Translate a cluster of lines into a volume or surface.

3. Try to denote existing and non-existing (desired) movement in the site. *How?*
   - Analyse the current movements in the site.
   - Imagine where future movement takes place and where it should take place.
4. Identify nodes and directions in the movements.

3.2.2. Phase 2: The diagram

5. Think up what is essential to the design task. *How?*
   - In the Moebius house for example, the Moebius band is related to the connection of two people living in the house.

6. Find an image that captures the essence of the design task: the diagram. *How?*
   - A diagram depicts structure, organisation, or forces.
   - A diagram may not depict something from the architectural domain.

7. Determine principles from the diagram that help in form-making.
8. Connect the diagram and design indirectly (e.g., not "this line in the diagram is a wall in my design" but "turbulence in the diagram forms the basis to think about circulation in the building.")

► Figure 2: Example of student work using van Berkel's design method.

3.2.3. Phase 3: Reflections about the design

9. Van Berkel's working method is a mix of analysis and free interpretation.
10. Argue how the analysis of movement and the brief influences your design.
11. Argue how the diagram influences your design.

3.2.4. Example of student work

The students took for the diagram the notion of drifting ice. From that phenomenon, they took the way shards and pieces of ice are pushed against each other as a way of structuring volumes in the exhibition pavillion.

3.3. Greg Lynn

Greg Lynn's primary notion is that space, and the architectural objects in space, is dynamic and can be made computational [63,64]. Shape, in his view therefore, is determined by the forces to which it is subject. Among others, these are the brief, the site, and the structure of the building design. A recurring example is the hull of a ship, which curvature reflects the existence of all kinds of forces that act on the ship. In the same sense, Lynn searches for the forces that act on the shape of a building. By setting these forces on a structure, he can investigate the effects of the site on the design. This is done through animation of the form. By freezing the form in a particular constellation, Lynn aims to capture the characteristics of the site and brief in the building design.

3.3.1. Phase 1: Analysis

1. Determine in the brief the most characteristic elements of the design.
2. Determine of each element: minimum en maximum size, relation with other elements, relative position, attraction and interactions.
3. Determine which representation is most suitable (spline, surface, blob).
4. Make a structure that connects all elements.
5. Relate the structure to the site and determine the influence of the site. *How?*
   - What are (im)possible locations of elements?
   - At which places are high or low concentrations of elements to be expected?
   - Can elements be further transformed by the site, for example because of (traffic)movement or other properties?

3.3.2. Phase 2: Animation and study

6. Place the elements on a timeline and key frame important properties (place, size, etc.) *How?*
   - Define start- and end condition on the timeline.
   - Determine at least two or three other configurations and place these on intermediate frames.
   - Model interrelations between objects.

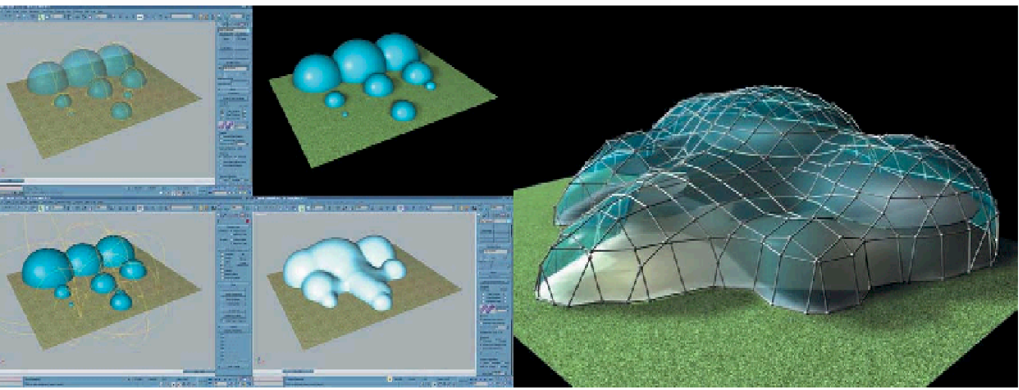
7. Animate the object.
8. Study the interactions between the objects themselves and between the objects and the site. *How?*
   - What place do they take?
   - What size do they have?
   - Which objects cluster and which objects fragment?
   - Can all objects be captured in a single volume?

9. Refine the key frames and animate the object again, or choose a configuration as starting point for the design.

3.3.3. Phase 3: Reflection about the design

- The configuration from the previous phase still takes much work before it is a finished design. *How?*
  - The resulting shape often only is a surface model (depends on working method).
  - Choose a building technique to materialise the design. Lynn often uses a grid-like structure for bearing the walls.

▼ Figure 3: Example of student work using Lynn's design method.



3.3.4. Example of student work

In the example, the student first analysed the functional brief of the design task (an art pavilion), then related blobs to the elements, defined interaction and forces between the blobs and had the software (3DStudio MAX) compute the results. This process cycled in particular through the refining of interactive forces. The resulting shape was further developed with a structural system.

4. Discussion

In the assessment of the effectiveness of the current approach, we have to distinguish between the following aspects:

- Research methodology of the framework.
- Quality of the found design methods.
- Application of the design methods by the students.
- Quality of the resulting designs by the students.

4.1. Research methodology of the framework

As described previously, development of the framework occurs in the following stages:

1. Selection of text fragments and images about ontology, CAAD, and method.
2. Identification of theoretical concepts for the ontology, and establishing relationships between these concept.
3. Establish a chronological order for the use of the concepts in a design process.
4. Correlate the images with the design chronological order to illustrate the design method.

The current work has two major limitations: (i) the establishment of the design method is at step 3 of framework development highly conjectural and subject to personal taste; and (ii) it is not possible to distinguish between the architect's normative position and the actual design process. By limiting the conjectural phase to one step only in the development process, we aim to keep the most interpretative phase restricted to this particular step only. The other steps can then form a ground for a more objective comparison of relevant concepts with respect to the design method of a particular architect.

The concepts of the framework: ontology, CAAD, and design method, can be used by students to quickly grasp the implications of the computer in the design by other architects and also as it is used by themselves. The applicability of the methodology as such has limitations. Because the methodology relies on written documents, it can only be applied to other architects when there is some body of written material by the architects or others about them. Furthermore, the written documents need to contain material from which it is possible to derive concepts for an ontology, statements about the use of the computer, and statements about the design process.

4.2. Quality of the found design methods

The design methods that are derived using the framework above, are very specific for each architect. They aim to provide a stepwise plan in which important issues to a particular architect are outlined in chronological order. As stated above, in this work we have to adopt the normative stance as we have no means (or desire) to question the actual use of computers in the design process. However, the resulting design methods can form a basis for comparison with such studies, to determine the differences between normative positions and practice.

4.3. Application of the design methods by the students

The degree to which the design methods are described, evolved during the time that the course ran. In the first year, the stepwise plan appeared to be too simple, leading to the currently described more explicit stepwise plan, including the how? sections. Later, examples of diagrammatic images and diagrams were included in the teaching material, as students were having difficulty selecting sufficiently complex diagrams for the designs. In the future, changes to the pedagogical approach of the course will lead to a more structured phase of the theoretical lectures to better suit the design task. Overall, the students followed the stepwise plan of the design methods correctly.

4.4. Quality of the resulting designs by the students

The students were required to submit a report with the following items: (i) clarification which method was chosen, with motivation; (ii) clarification how the method was applied; (iii) commentary how the method was perceived and used; (iv) reflection on the method and its use; (v) reflection on computer aided design in the context of the work. Those students who made an urban design had to submit an indication of type of the student housing, a plan of the urban design, representative perspective drawings or renderings, bird's eye view of the plan, and location of the art pavilion. The students who made the pavilion, had to submit facades of the pavilion, representative sections of the pavilion, interior and exterior perspective drawings or renderings, volumetric indication where student housing should be realized on the site.

The kind of designs that were the results, and the range in quality of the designs varied greatly. It did not seem the case that the design methods influenced to a great extent to final appearance of the designs. What did appear to be the case, is that through the use of the design methods, all students were comparably comprehensive in their scope of dealing with the issues that were important in the design methods. Differences in quality occurred mainly in the depth of treatment of each of these issues.

4.5. Comments by the students

The presented work generated comments from the students about two main topics:

- The role of chance in the design process.
- The role of design methods for architects.

4.5.1. The role of chance in the design process

By presenting the working approaches of the architects as design methods, the design process becomes more transparent. The stepwise plan revealed for each architect a number of particularly sensitive phases when choices have to be made. In the case of Eisenman, for example, this occurs throughout the choice of key elements from the historical material and the influence of the diagrammatic image; in the case of van Berkel this occurs when the diagram has to be chosen and determined how it will influence the design; and in the case of Lynn this occurs when the influences of the site on the dynamic system has to be defined. These phases were often equated by students with randomness or chance because from the method alone they could not grasp the rationale behind the design decisions. In particular those instances serve as good occasions when to discuss the work of the architect, his or her architectural theoretical position, and the use of CAAD.

4.5.2. The role of design methods for architects

Based on the reports, the students responded differently to the theoretical section of the course than to the exercise section. In general, with respect to the theoretical section, all students agreed they had gained a better insight in the use of the computer in the design process, and that they could better reflect on their own use of the computer. In the design exercise, unless a student already had affinity with a particular design approach, most students felt they were 'forced' to work like someone else. Also, those students who did not have much affinity with using the computer in the design process at the start of the course, still did not have much affinity after the course – although they reported a better understanding of its use (perhaps to console the teacher).

Based on this, we feel there is a distinct difference in learning about design (methodology) from a theoretical point of view and applying design methods in a design process. Where the theoretical section is abstract and distant, requiring the use of a design method is a confrontational experience which quickly highlight similarities and differences, as well as affinities and dislikes of a student with a particular way of working. It serves as a starting point for students to articulate their own position and to understand the positions of others.

5. Conclusion

In this paper, we have presented a new approach to deriving design methods based on written documents by or about specific architects. This approach is based on a filtering of key concepts under the headings "ontology," "CAAD," and "method." Deriving design methods on this basis is to some extent a speculative process, which limits the wider applicability of the found design methods. The framework is particularly useful for identifying quickly important issues for a design approach, and to understand the use of the computer in the design process. Although the derived design methods are very specific to a particular architect, the resulting work by students varies to a great extent. Design methods aid in tackling the relevant issues as posed by the architect; this as such does not guarantee quality of the outcome. The use of design methods highlights sensitive phases in the design process where design rationale is no longer solely based on the design method itself.

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