Structured Reflection as a Means to Deepen Understanding of CAAD

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Abstract. *In this paper we outline a strategy of structured reflection to improve reflection by students in a course on the implication of CAAD, design theory, and design methodology. Earlier editions of the course showed that students often did not evolve their learning beyond a checklist level. Reflection is an important mechanism to improve learning from design situations. After a consideration of the main approaches to design reflection, we take up Schön's notion of reflection and provide support for structured reflection in CAAD education, based on earlier experiences with structured question lists in a civil engineering course. . Findings after the first year's run show a deeper level of reflection on a more elaborate level.*

Keywords. *Structured reflection, CAAD, education.*

Introduction

The current paper is written in the context of a course on advanced CAAD modeling. This course is running since 1999 in the third year of the Bachelor program Architecture Eindhoven University of Technology (presented earlier in Achten, 2001). The course treats a variety of architects (Eisenman, van Berkel, Lynn, and Gehry) who use the computer in their design process, and discusses the relationship between CAAD, design theory, and methodology. Based on this, students have to apply a generalized form of the architects design methods (the above mentioned except Gehry) to a small design task. In this way, they are confronted maximally with someone else's working method and their own design process. The aim is that this leads to insight about the impact of CAAD on design in general and in the student's own design process.

When evaluating the outcomes of the course, the following observations could be made:

Students appreciated the connection between design theory, methodology, and CAAD. It was, however, not clear from the delivered work to which degree the design theory was understood. The application of the work in later projects showed a kind of checklist behavior without deep grounding of the theory.

In later projects, design methods from the course were spontaneously applied in projects by the students (there was no involvement from the teacher, nor were the students required to apply some or other method).

Many students applied the various CAAD techniques in roughly the same order as the design methods prescribed. This is easily verified through the delivered works of the design and the

CAAD models. With the exception of some students many of the processes were quite linear and showed 'checklist' behavior: a student was satisfied with the process once a prescribed phase was concluded and did not return on it even when faced with difficulties later. Students were asked to reflect on the process and the technique, but this was seldom deeper than remarks on the applied techniques.

To reach the learning goals of the course, the learning process should be improved. Learning situations require that the learner, after receiving feedback about his or her results, reflects on the effectiveness of the actions taken. Kolb (1984) includes in his experiential learning cycle the following steps: concrete experiences, observations and reflection, formation of abstract concepts and generalizations, and testing concepts in new situations. Reflection is one of the most important steps in this cycle. Based on our evaluation of the course, it seems that the reflection part of the course was underdeveloped and should be strengthened. We therefore looked at reflection in literature, more specific reflection in design education. Structured approaches to reflection that can be applied in CAAD educational settings are however not yet available. Based on general literature about structured reflection and some experiences with support for structured reflection in engineering education, a structured checklist for reflection in CAAD education was built. This checklist was used in the last version of the CAAD course (2005). Based on some criteria to judge the learning process, the reflection results of the old and new version of the course were compared. From this comparison, conclusions about the structured checklist could be made.

Towards structured reflection in design

There are two major orientations in the description of design (Dorst, 1997): Rational Problem Solving, launched and defended by Simon (1969); and Reflective Practice, launched and defended by Schön (1986).

The main contribution of Rational Problem Solving (RPS) to design is the analytical process of analyzing the design problem, subdividing it into more comprehensible pieces, and sticking to this sub division while attempting to solve all sub problems. This approach is very powerful, but it faces two severe problems in the area of design. First, in the face of difficulty, it does not indicate when and how to make a new subdivision of the problem while keeping consistency. Second, it does not tell how to integrate sub solutions in a meaningful manner. Furthermore, it has to be noted that RPS takes a prescriptive stance to design problems: it does not say "this is how designers do it," but rather "this is how designers should do it." Critique on RPS then is often parried by pointing to a lack of sufficiently worked out techniques for design. For the description of design therefore, RPS shows shortcomings. The authors of the Basic Design Cycle (Roozenburg and Eekels, 1995) even abandon a prescribed order under the stipulation that in a design process, any action has been performed at least once.

The main contribution of Reflective Practice (RP) is that in descriptive terms, it seems much closer to the experience that designers have of their design process. It steps away from the sweeping theories of RPS and offers a simple, four-step structure that occurs in a design process: naming, framing, moving, and evaluating. Rather than structuring the design problem or process in a predetermined way, according to RP designers construct throughout the design process on the fly their situation by naming what is relevant in the problem, and then framing their action in order to move ahead. While appealing to designers, the concepts of RP have turned out to be notoriously difficult to clearly define in two respects (Dorst, 1997; Valkenburg, 2000). First, what criteria to handle in order to identify naming, framing, moving, and evaluat-

ing activity in a design process; and second, criteria to determine what actually constitutes good naming, framing, moving, and evaluating. In the latter sense, RP fails to deliver prescriptive notions for good design.

Neither orientation of RP and RPS seems sufficient to fully explain (or direct) design activity (Dorst, 1997), so currently, we do not have an overarching theory what design activity is (Achten et al., 2005). As serious as this is for the general field of design, it also leaves (CAAD) education wanting for an adequate framework for teaching, including the aspect of reflection. RPS is mainly focused on the problem and its solution. Therefore, reflection in RPS basically means evaluation of the design respective to the stated requirements, but does not take the process into account. RP stresses quite hard the aspect of reflection. Since reflection in RP is particularly focused on the sequence of naming, framing, moving, and evaluating, it is much more embedded in the process, and thus seems more appropriate in our case to consider.

Schön distinguishes three kinds of reflection:

Reflection in action: the designer is thinking about what (s)he is doing while doing it, in order to monitor or adjust future situations.

Reflection on action: the designer is thinking about what (s)he is doing after one or more actions, in order to monitor or adjust future situations.

Reflection on practice: the designer is thinking about what (s)he has been doing in one or design projects, in order to understand his or her own design patterns.

An overview of research performed on the three types of reflection can be found in (Reymen, 2003). Most of the prescriptive research focuses on reflection on action; for reflection on practice, no support is developed yet.

Reflective practice in (caad) education

It is perhaps surprising to note that although everyone seems to have heard of RP, there is actually not much work done on a structured or rigorous measurable application of reflective practice in design education. Adams et al. (2003) give insight in how engineering education can be improved using Schön's reflective practitioners theory, although no concrete support was developed yet.

Within the area of CAAD, we can only find a limited number of contributions. McCall et al. (1989) present the Janus system, which is intended to support or promote reflection in action. Reflection in their system is much geared towards argumentation, and thus more to constructing design rationale rather than immediate reflection on the preceding naming-framing-moving sequence. They point out that there are two kinds of reflection: triggered by violation of principles of design, and reflection on the general principles of design.

Burry et al. (1991) stress that reflection-in-action is one particular mode of learning that freshmen students have to master when they enter an architecture curriculum. Although they explicitly claim to base at least part of their educational work on reflection in action, the paper provides no evidence how this is structured in the course.

Clayton et al. (2001) look at reflection from the outsider point of view, to be more precise not the reflection of the designer, but reflection of the teacher on the design activity of the student. They present a number of examples how an integrated analysis of information processed during studio work can give clues how processes may be better structured for students. Unfortunately, the paper does not provide findings from such analysis.

Datta et al. (2001) aim to improve reflective making through a rather abstract pedagogical template structure. The reflection that should occur is only hinted at and not further described or structured. In a related paper, Woodbury et al. (2001) aim to foster reflection in action, but again, no further indication for achieving this is provided.

Structured reflection for caad education

The kind of reflection we want to support in the CAAD course in the Design Systems group of the faculty of Architecture, Building and Planning of Eindhoven University of Technology is reflection on practice. We therefore build on the work of Reymen (2001), who developed a first method for supporting structured reflection on action performed by individuals. The method has been tested, improved, and extended in several design courses in engineering education. Currently, structured reflection on practice is applied in a design course of the Civil Engineering Program of the University of Twente. In this structured reflection, students are required to address a number of specific design process-based questions. We have adapted the list to include more specific aspects of the CAAD course (Table 1). Students have to apply in our design task a design method by one of the architects discussed in the course. This confronts them in their design process with design sequences and considerations other than their own.

As can be seen from the list, the majority of questions deal with the confrontation of using the design method, its implications for the design process and result, and the degree to which students found it useful.

Table 1. Structured reflection list of caad course.

The design task

Was the method suitable for the design task (student housing or pavilion design)? To what degree; in which sense?

Was the task easy to understand? Where did you have difficulty? What was not clear? How did you overcome the unclarity?

Was the task complete, and if not, what did you have to add? How did you decide what was missing; how did you find it; how did you use it?

What did you have to add from the use of the method? What material, information, work, and so forth; and at which point in the process did you find out?

The aspects of the design method (theory)

Did you understand the theory before you started with the design task? Could you explain it someone else? What questions did you still have?

Did your ideas of the method change (much) when you used it in the design task? What changed, and how? Did you like it better or worse, or did it not matter? Why did your ideas change when using the method?

Did you understand the theory better or worse after using the method in the design task; or did it make no difference? What aspects of the method became more (or less) clear for you? Why? How?

Could you apply the method easily to the design task? If not, what were the hard parts, and how were they hard (work, complexity, unclear, etc.)

Did you feel that the method was complete? Did you miss something after you were finished with the method? What did or would you add to make it more complete?

Your choices in this assignment

How much did the design method help in making the choices throughout the design task? Did you have to make many additional choices? Where these additional choices critical in your view? Where your additional choices consistent with the method or contradictory?

Did the choices prompted by the design method make a difference in your view to the design result? How so? In what way?

The problem formulation

Does the design method help formulating the problem in such a way that you can start designing? If yes, in what respect? If no, what did you find lacking?

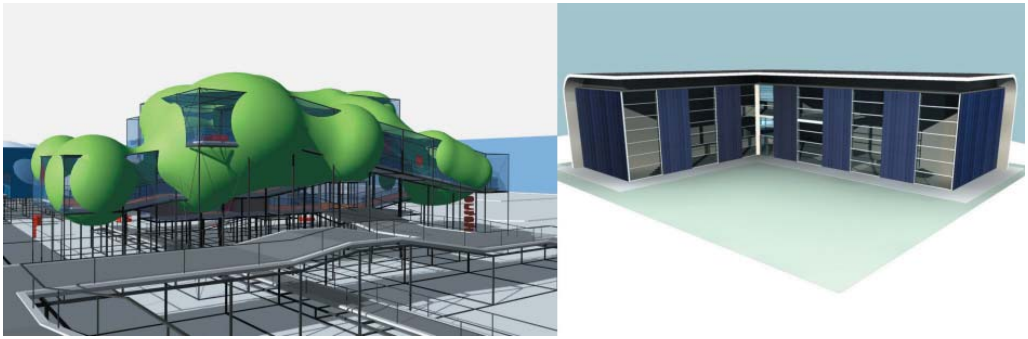

Figure 1. Student work by Daan Willems (left) and Jeroen Mak (right).

The result

Do you feel the result is a by design by your hand? How much of you is in the design? Can you relate to the design outcome?

Do you feel the design is a whole concept design? Does it feel rational, can you explain it?

The design process

Did the method force you to think about specific aspects more than otherwise? Was this helpful or distracting for you, and in what way?

Was the order of the process logical for you? Could you follow it without problem, or did you have to change the order of things?

The team composition

If you made the design in a group, how were the tasks arranged between the members? Was the method helpful for this? Did the management of tasks take a long time or not?

Learning effect

What have you learned?
What was difficult?
What should you do differently a next time?
What can still be learned?

Other aspects that were recognized If there are other aspects not included in the list above, then please include these as well.

The computer techniques

Did you learn new techniques?

Did you learn to apply techniques you already knew in new ways?

Was the framing of techniques in an architectural theoretical way helpful for you?

Can you now review your previous work with CAAD techniques in an architectural theoretical context?

Can you describe your own preferred way of working now more precisely?

Criteria for judging reflection by students

Students were required to write a reflection of about 4 pages A4 guided by the questions in Table 1. The reflection should form a coherent record and not follow the list point wise. The reflection was judged on the following aspects:

Comprehensiveness with respect to the issues mentioned in Table 1.

Depth of the reflection: are the aspects discussed in some length, and not just with a simple yes or no.

Consistency of the report: are there no internal contradictions in the reflection text or contradictions with the delivered work.

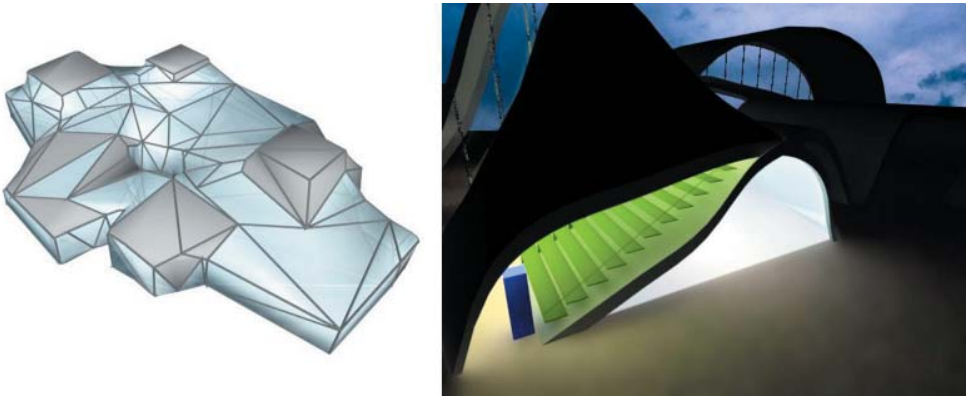

Figure 2. Student work by Léon van Berlo (left) and Paul Bos (right).

Structured reflection by students

Not surprisingly, compared to previous years, the reflection part of students work was substantially increased in quantity. By structuring the reflection as indicated above, a much greater deal of discussion was spent on the design process. This increased attention lead students away from the previously often made observation about the role of chance in the design process (Achten, 2001: pp. 87). The more detailed considerations of the influence of theory and the use of CAAD in the design process made the students more aware of the interactions between these factors.

Similar to previous years, the students reiterated the confrontational nature of working with someone else's design method, and they all acknowledge that this is helpful to understand the work methods of the architect in question. For most students, this design task was the first in which CAAD was integral from the beginning of the process. Therefore, the comparison with their 'regular' design process was difficult to make. The course did increase their awareness of the usefulness of CAAD in the design process, in particular since it was applied in an architectural theoretical context.

The architectural theoretical context proved for most students useful as a structuring and guiding principle to apply CAAD techniques. From several comments, it was obvious that more tutoring was required on the techniques themselves as they often formed a slowing factor when students had problems mastering the techniques. However, these obstacles also lead to a better appreciation of the effort involved in the (seemingly effortless) imagery of 'computer architecture' offered in architectural journals and books.

The design task gave students a better insight in the 'stylistic' scope of design methods. They were better able to identify to what extent a method is a guiding principle, and when it stops being helpful to the process. Also, they were better able to assess the impact of a design method on the final appearance of a design. Most of the students felt that the resulting design was 'their own,' while also acknowledging that in the future, they would not re-use the chosen method – but it is also not the intention of the course to create 'Eisenman,' 'van Berkel,' or 'Lynn'-clones. Overall, we noticed an increased quality of reflection by the students.

Conclusions

We reached our goal in the sense that we developed support for structured reflection in our

CAAD education. We do, however, only support reflection on practice. Further research is needed to support the other types of reflection in our course to further improve the learning process. The recent work of Lawson, Dorst and Reymen (Dorst, 2003 Dorst and Reymen, 2005) may be helpful in this regard. Also, only individual reflection is supported, whereas in many education situations, teams have to reflect on their design process. The application of the checklist in other CAAD courses should also be further investigated.

The structured reflection leads to a more explicit verbalization of the student's experiences during the design process, simply by virtue of having to write it down. It is too early yet to observe if this leads to a deeper understanding which is transferred to other situations in the students' design work (other projects). Nevertheless, the original experiences with the structured reflection approach in Twente make us hopeful that this effect will occur.

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