

Designing with the computer: the influence of design practice and research

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Abstract: The paper describes the setup and development of an advanced course in CAAD in the framework of a particular teaching environment and the democratization of computing technologies. It traces the transformation of goals and means for the course as a result of changing priorities and interests towards a form that agrees with emerging cultural patterns as observed in architectural education.

Introduction: the evolution of the digital design studio in the democratization of the computer

In the last fifteen years the democratization of the computer has changed the image of digital design media. More significant than the efforts of the CAAD academics and practitioners, the dawn of the computer era has created an increasing popular interest in information and communication technologies (ICT).

Interest in ICT stems from the combination of (a) the wide availability of affordable computer power with (b) the emergence of popular ICT applications, mostly in the areas of entertainment and information services. Such developments signify that we are entering the first stage of the digital revolution proper, the *democratization of ICT*. Until recently computational technology has been the preserve of an elite, the research and development community of the academic and corporate world. This elite has been instrumental in the evolution of ICT during four rather troubled decades. Lately, however, it has been suddenly overtaken by wider social and technological developments that have absorbed many of its results and ideas without integrating its members and preoccupations.

Architectural education is also experiencing the effects of the democratization of ICT. In the past CAAD researchers and educators have been responsible for a number of exclusive tasks. These included:

1. The basic acquaintance of students with computer and design computing technologies (computer and CAAD literacy).
- Development of approaches to the computerization of design (fundamental research).
 - Development of computational instruments for design practice (applied research and development).

Central to these tasks has been the duality (and frequent ambivalence) of method and technology in architectural computerization. The CAAD community has always claimed that the technology it transferred to architectural design relied on methodical design principles, if not on a complete design methodology. With the democratization of the computer the technological component of CAAD has become accessible to all. One would therefore expect that in CAAD teaching and research the methodical component would become the dominant aspect. However, the democratization of ICT and the consequent integration of digital techniques in the analogue design studio have relegated the CAAD specialists to a subordinate role, as the technical assistants (task #1) to the design teacher. This is largely due to the weakness of the methodological component in most CAAD approaches. The adoption of superficial proscriptive and prescriptive models of design without sufficient cognitive support and relevance to practice has rendered such approaches irrelevant to the cultural climate of the computer era. It is however ironic that the conventional design approaches CAAD research has attempted to refute are now overtaking it and reducing it to the level of support.

As a result of the inevitable subordination of technology to designing, educating the new CAAD specialists capable of understanding and utilizing new technologies becomes increasingly harder. So long as demand concentrates on the technological aspects the CAAD specialist is in danger of becoming a mere power user. Moreover, it may result into forms of diversification, which may enlarge the CAAD market but could also lead research and teaching astray. For example, the evolution of ICT into a ubiquitous infrastructure is frequently coupled to spatial metaphors and interfaces. These could form a new application area for CAAD and absorb new CAAD specialists to an even larger degree than computer visualization in the entertainment industry.

The most unfortunate effect of the excessive attention to computing technology is that the utilization of existing knowledge (task #2) is essential to the solution of actual problems in practice (task #3). Despite the high profile of ICT in practice, the truth is that for the majority of users the computer is a mere digital drafting table. A close examination of computer drawings (but also of other documents, e.g. texts) reveals a severe lack of structure, meaning and purposefulness that makes them fit only for printing. Using such documents as valid representations for e.g. design analysis makes absolutely no sense. However, it should be pointed out that putting effort and time into a structured representation presupposes utility of the representation, i.e. concrete, beneficial applications, which would have been infeasible without it. It is the absence of such applications that reduces the computer to mere drafting for printing.

The D7 in context: roles and ambitions for a course in advanced CAAD

In the beginning of the nineties the Faculty of Architecture, Delft University of Technology, introduced *problem-based learning* in the teaching curriculum. This change of didactic approach also necessitated a radical restructuring of teaching, especially in the first two years. These were organized in a number of *thematic blocks*. These initially twelve and later ten blocks comprised a variety of subjects, all nominally focused on parts or aspects of their corresponding themes. The blocks would form a sequence that would provide a progressive, coherent acquaintance with the essentials of architectural training. For practical reasons the idea of a single sequence was soon abandoned in favour of two and later three alternative trajectories. In practice students could and did follow the blocks in practically any order they happened choose with very few constraints.

This teaching reorganization also brought on the introduction of a compulsory comprehensive CAAD curriculum. Four of the second year blocks included CAAD exercises, which addressed CAAD literacy and integration of CAAD in design. These exercises represented the first attempt to reach all students of the Faculty and cover all application areas in architecture. As a result of the prerequisite integration into the blocks and of the arbitrary order of blocks, the coherence of the four second-year CAAD exercises was rather low. The courses retained the episodic connection of computing technologies to design situations that characterizes current CAAD teaching but could not relate these episodes to a sequential backbone.

The missing backbone was to be provided by *D7*, the final course in CAAD. The *D7* is an elective course for third and

fourth year students, jointly organized and supervised by the architectural design and CAAD groups. The D7 was intended as the culmination of the CAAD courses at Delft: a design studio where students analysed existing buildings, organized the design process and solved architectural problems exclusively by digital means. The goals of the course were to:

1. *Introduce students to advanced computing technologies.* These ranged from specialist subjects only partially covered in the second-year exercises, such as advanced animation techniques, to technologies not yet fully transferred to CAAD, e.g. rapid prototyping, scientific visualization and robotics.

- *Round off students' technical knowledge of computing.* The rapid evolution of computing requires that the CAAD specialist possesses a deeper understanding of the technologies involved, also at the technical level. The ability to understand low level implementation problems and guide their solution on the basis of their purpose is still a non-trivial issue in both research and practice.

- *Link computing to architectural design problems.* This was seen as the core of the D7. Devising links between actual design problems and the possibilities of CAAD methods and techniques is becoming increasingly hard. Despite (or probably due to) the explosive growth of available and affordable technologies, solutions that go beyond what is apparent are rare. Linking computing to architecture requires a deeper understanding of the computational principles of current technologies and a thorough analysis of architectural problems and processes .

- *Provide an overview of digital design theory and methodology.* This is clearly a prerequisite to the previous goal, as well as the main aspect missing in the second-year exercises. It was assumed that the popularization of ICT would on the long run diminish the current emphasis on technology and isolated solutions and build more on the methodical component of CAAD.

The course was structured as a series of experiments organized around drawing and modelling exercises. The CAAD teachers supervised each experiment on a daily basis. Design teachers operated more as guest critics and concentrated on design quality and relevance. The experiments demonstrated the capabilities and limitations of design computing in specific design situations and stimulated further focused study of digital methods and techniques. The only exception was the overview of digital design theory and methodology (goal #4). This was provided through lectures, visits to architectural offices and literature review. Literature review and lectures also complemented the experiments but there the implementation component was the main means, in accordance with the nature of goals #1 to 3.

The extent of current computer and CAAD literacy and the variable entry level of students necessitated that the D7 structure and contents were kept flexible. Students were even allowed to devise their own experiments, usually as variants of the given ones. Together with the input of the design teachers, this resulted in a course responsive to demand. Soon it became evident that demand was focused on two main areas, visualization and communication.

Computerization as visualization (or visualization as computerization)

Not so long ago a large proportion of the CAAD community tried to impose an unfair picture of drawing as an activity that should be contrasted to design. Numerous novel representations were proposed but soon disappeared from the public eye, with a couple of notable exceptions. Drawing remained a primary CAAD area, especially in practice, where the largest part of automation is geared to the production of drawing documentation. The proliferation of reasonably powerful hardware and software complemented the traditional drawing facilities with new visualization tools. These held a particular fascination to students and design teachers alike.

The reasons for the general interest in visualization are not new. Architectural design has always been characterized by

a visual bias, which is evident in the strong preference for visual representations. The overtly visual architectural culture with its deep roots in our predominantly visual interaction with the built environment has been one of the constant factors in architectural practice, design and education. Recently, however, it has been undergoing an initially subtle transformation. The D7 attempted to make this transformation explicit by focusing on three main roles for digital visualization.

The first and most basic role for visualization is the representation of architectural form . Digital modeling is arguably the first technology that permits a comprehensive analysis of the relations between geometry and architecture. The analysis of existing complex buildings through digital models reveals the use and abuse of geometric principles in architecture . Current digital tools permit a more reliable geometric justification of architectural form, which is moreover linked to construction through technologies such as rapid prototyping. Such links facilitate technology and knowledge transfer from other disciplines and professions. For example, learning dynamic visualization from the film industry provides useful examples of modularity and partiality in representation.

Visualization is also becoming important to the analysis of buildings and designs. Drawing from technologies such as simulation and scientific visualization we apply digital visualization to the task of projecting building behaviour and performance . Aspects like lighting and air circulation can be visualized by rather reliable, precise and accurate realistic images. These are moreover linked to analytic representations that facilitate communication with other disciplines that contribute to the design of the built environment, such as lighting and HVAC specialists . In architectural education visual analyses are also important for a rational, multidisciplinary treatment of design problems.

The third role for visualization concerns the extension of architectural knowledge to virtual environments through the spatial metaphors and interfaces of the Internet and cyberspace . The design of such environments is becoming increasingly popular in design education as an alternative employment area for the digital visualization expert. While it is too early to speculate on the significance of cyberspace as a subject of architectural design practice, virtual environments deserve a prominent place in architectural education as the technology that could bring together the fragmentary, multidisciplinary building industry.

Student response to focusing on these subjects was probably the most rewarding aspect of the D7. While design teachers frequently failed to comprehend the appreciation of a search for an appropriate visual representation, students were generally capable of overcoming the frustration of temporary failure and appreciate the value of the search as a learning process.

Communication problems

The democratization of ICT allowed the introduction of a few novel forms in CAAD education. Probably the most important such form is the *virtual design studio*, where design communication and collaboration takes place through the multimedia technologies of the Internet . The popularity of the virtual design studio in the mid-nineties was soon tempered by saturation with technological exhibitionism and bandwidth problems. Nevertheless, it opened new possibilities in presentation and visualization for communication.

In the D7 the virtual design studio assumed the conventional form of collaboration with another school abroad, namely the ETHZürich . In this collaboration the students of the one school acted as clients and critics of the students of the other school and vice versa. In this framework it was possible to explore the possibilities and limitations of the Internet as a communication medium, as well as cultural differences in designing between different schools and countries.

The main problem with the virtual design studio is that, despite its usefulness as a demonstration of future communication modes, it remains a one-off experiment –unless of course it becomes an unobtrusive component of a wider collaboration scheme. Repetitions of a virtual design studio on an ad hoc basis lead to little beyond optimization of tools and schedules. For this reason in the D7 emphasis soon shifted to the technologies involved in computer-based

communication (i.e. the prerequisites to virtual collaboration environments) and in particular to the presentation of design proposals on the Internet. Such presentation entails integration of design representations and analyses from conventional CAD and modelling programs in Internet documents.

In our exploration of digital architectural presentation we chose to disregard the aesthetic side and practical aspects such as completeness of information. Instead we focused more on issues pertaining to the role and structure of the information carriers. These ranged from the methodical (e.g. relations between representations, feedback and links information systems) to the technical (i.e. choice of conversion and integration techniques, as well as tools for the utilization of the presented images).

One issue that requires particular mention is the linking of virtual design environments and presentations to information systems. The plethora of on-line information types and sources for the building professions has two important consequences. The first is that the utility of available information presupposes not only reliable and efficient techniques for the integration of external constraints and components in a design representation but also new approaches to the collection and dissemination of actual and accurate information. The ability to make available such information and share it through individual Internet presentations is one of the most promising contributions of ICT to the improvement of architectural quality.

The second consequence is that CAAD is extending to the development of data structures, database management systems and interfaces of on-line information for architectural use –a refinement and scaling down of the design of virtual environments discussed in the previous section. Combined knowledge of architectural design and computing technologies can lead to more efficient and effective solutions for the building professions, especially if attempted in a bottom-up, ad hoc fashion (i.e. from within a specific practice) rather than as a procrustean, top-heavy norm.

Further development

The success or failure of a course can be measured in two ways. The first is its popularity among students and student performance in the course. The second is the satisfaction of the goals set by the teacher. In the case of an advanced CAAD course like the D7, the first measure is arguably inadequate. The current popularity and wide acceptance of computing in design outweighs the merits of a particular course, as most students realize that computing knowledge and skills are becoming general prerequisites to finding employment.

The second measure, satisfaction of the initial goals, should also be subject to scrutiny. The duality of method and technology in CAAD has often resulted in failure to have a positive impact on architectural practice. While the duality itself and the subordination of implementation to method are cornerstones of computerization, CAAD has tended to focus on rigid prescriptive and, less frequently, proscriptive methods, which neglected many practical and cognitive issues. As a result, many CAAD products are irrelevant to design practice and incompatible with the wider development of ICT.

One of the reasons for the episodic structure of the D7 was to avoid imposing a particular approach as a prescriptive or proscriptive model of designing. Each experiment was studied more or less in isolation from unconnected general issues. This facilitated concentration on and comprehension of the design problem in relation its possible computational solutions. On the other hand, however, this structure did not support detailed, in-depth treatment of each design problem, or the consequent production of designs of high quality. Unfortunately this is what most design teachers and a fair proportion of students took for granted. It appears that the democratization of ICT has once again led to a general, ungrounded optimism as to the direct applicability computing to designing.

A basic reason for this is lack of understanding of the relevance of design computing to design practice. Students learned relatively easily how to use conventional and advanced systems but frequently failed to apply them in a way that resulted in an improvement of design performance and quality. We attributed such lack of understanding to three

reasons:

1. The distance between the theory of design computing and computer use in practice meant that CAAD teachers often had to make precarious leaps in explaining relevance and applicability issues.

- Most students were quite unaware of the extent and character of actual design problems that can be resolved computationally.

- Design teachers were generally unfamiliar with computational methods and techniques. This often led to superficial and simplistic advice to the students.

One solution to such problems is the integration of research results into the course. As this research focuses on the development of focused systems for practice, it turned out that the CAAD specialists were capable of analysing a range of practical problems and outlining their computational solutions. Students could subsequently experiment with the given constraints and attempt to comprehend both the problems and the solution by actively exploring the subject. However, these applications remained a subset of the spectrum of possibilities with current ICT. Exploration of this spectrum is one of the students' priorities that should be encouraged as a healthy and productive form of academic curiosity. Moreover, this exploration is a frequent necessity because many students come to the D7 with a minimal understanding of CAAD, despite having followed the second-year courses.

We expect that the problem of computing and CAAD literacy will diminish as students become increasingly exposed to ICT prior to entering the university. The problem of relevance will however remain and could probably be further accentuated by ungrounded expectations. We are currently concentrating on a solution to this through the reinforcement of the episodic structure of the course against a comprehensive background of design and computational methods. Each experiment in the course becomes a problem that should be fully resolved with a qualitatively satisfying design. The resulting design-oriented structure is related to computing technologies and design methodology through readily available on-line documentation. In other words, instead of imposing a particular approach that determines the applicability and utility of design and computer tools, we ask the student to select these tools and adapt them to the constraints of the problem in hand. This approach obviously increases the intellectual burden of the course but is probably better suited to the emerging patterns of learning through discovery and doing.

References