CAAD in pedagogical practice
Ann Hendricx, Herman Neuckermans, Han Vandevyvere, Kris Nuyts

The course on CAAD at the K.U.Leuven is part of the course on design methodology and theory from which it is the most recent and natural extension. Attached to this course a series of assignments has been developed which bring the students in 45 hours to a non-trivial level of acquaintance with CAAD. Our assignments are primarily directed towards practice. They are built on top of AutoCAD to which we have added in-house developments in order to focus on specific pedagogical goals within a very limited time.

After a general introduction on Windows (file management) and AutoCAD (basics) students make the following assignments (main pedagogical goals in between brackets): colophon (working with blocks), detail (2D-drawing, hatching, editing), façade design using a built-in system of proportion (slides, scriptfile), extraction (linking alphanumerical and graphical entities), container (level of detail, icon menus, viewports), surface modelling (modelling 3D-objects with surfaces), fractal tree (recursion in Autolisp), solid modelling (Leicester engineering building), lighting (integration of drawing and computation of illumination levels), pressure lines in an arc (interactive design of an arc), demos. The paper presents and comments these assignments and shows results from the last 2 years.

INTRODUCTION

By the end of the seventies the issue of design methods no longer was a hot topic. It was gently fading away when suddenly the advent of the PC reactivated the interest into the technicality of the design activity. CAAD quickly became the adage and pushed into the background the discussions about the legitimacy of the problem-solving paradigm for architectural design. The underlying confusion however about the relevance of systematic methods to design and subsequently about the role of computers in architectural design still exists. Therefore at the K.U.Leuven the course on CAAD is not taught as a mere instrumental skill but is embedded in a more general debate on design theory. This course consists of 3 parts:

Part 1 focuses on design epistemology: the discussion on the nature of design problems, modelling the design process, structuring the building programme, generation of ideas and selection of alternatives (the problem of weighing). It builds the argumentation for rejecting the idea of fully automated design. Part 2 brings a critical study of design methods or so called design methods: notation methods, decomposition, patterns, morphological box, master planning. Part 3 is devoted to CAAD and the topics are: definitions, hardware and software for CAAD, physical and conceptual modelling, the state of the art, prospective uses like case-based reasoning, intelligent objects.

Whereas the theoretical part on CAAD sheds light on what the domain really is, the exercises have the ambition to bring the students to a deep level of literacy in CAAD. The course on Design Methods is taught to 4th year students because we think the subject makes more sense.

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CAAD in pedagogical practice

to those who have already some design experience (from the 3 previous years). They all have had a course on computer science and another on systems software before they take the course on CAAD. This allows us to go further than just using existing software.

The CAAD practice can be taught at different levels. First of all, one has to become accustomed with hardware and software in order to explore the state of the art. This is the real learning phase. Secondly, the acquired knowledge can be used to customise existing CAAD applications to the personal needs of the user. Existing knowledge from different domains can be programmed and combined into helpful software tools. This developing step already assumes a more active attitude. Finally, creativity plays an essential role in exploring and conceiving new ideas and developments in the field of CAAD.

The CAAD exercises in the fourth year focus on the first two levels of acquaintance with the subject. Subsequently, those who like can penetrate into the creative phase by making a CAAD dissertation in their last year.

Since 3 years the practical course on CAAD is compulsory. About 60 students attend it yearly. Since we have 20 PC’s (IBM Value Point 486 with NEC 17 inch high resolution colour screens) in our computer class, we take them in 3 shifts of 2.5 hour sessions with one tutor per session.

The first sessions are devoted to general introductions on Windows and Autocad. In order to avoid unconscious promotion of Autocad, we also invite other firms to give a demo of their software (Microstation, Star, Minicad). The other assignments are shortly described and illustrated in the following pages (what), this in the sequence they are taught. Each exercise adds some specific skills to the students’ capabilities (why). For the sake of completeness, the time provided within the sessions and the time students really spent on the assignment are added.

REFERENCES

WHAT

Inspired by the practice in the architect’s office, we ask the students to create a standard colophon to use in all their future assignments. This colophon consists of a frame, alphanumerical information in form of fixed text and attributes, together with a logo for the student’s imaginary office. This colophon is to be inserted as a ‘block’ in a DIN-A3 prototype drawing, where general settings are explored and appropriate layers created.

WHY

Within a relative simple example, AutoCAD drawing and editing commands are exercised. Stress is laid upon accurate drawing (in a computer, the ‘more or less’ philosophy is taboo). The importance of organising a drawing is shown clearly in a prototype drawing. Secondly, the powerful possibilities of ‘blocks’ are explored: students have to see the great advantage a computer can offer by reusing (changeable) drawing components. Finally, to satisfy the need of exploring other window applications and to make this first acquaintance a pleasant one, the students are invited to use a simple drawing program like Paintbrush to create their own logo and import it into the AutoCAD drawing. Hereby, the difference between graphical packages (pixels) and design packages (vertices) is illustrated. Moreover, the possibilities of connecting and combining different applications are shown. To avoid confusion, this first exercise is kept strictly 2-dimensional.

STUDENT RESULTS

provided time within student’s agenda: 2.5h

some student logo’s, a prototype drawing with inserted colophon and a student colophon
WHAT

In the architectural curriculum at the KU Leuven, drawing of and reflecting on constructional details is very important. Standard ‘good’ solutions circulate within the faculty. Such a 2-dimensional detail has to be generated in an intelligent manner: a logical organisation of layers, colours, hatching and text is expected. Finally, the finished drawing has to be scaled accurately in order to print it in combination with frame and colophon of the previous exercise.

WHY

Drawing and editing skills are trained in depth. Moreover, this exercise emphasises the underlying organisation of a drawing: students have to decide what is the most appropriate way to use layers, pen widths, colours, hatching ... A persevering attitude to do this consequently throughout the whole drawing session is required. The representation of architectural components (cross section, elevation) is considered. By combining real size frames (prototype drawing) and a scale model, topics as scale/plotting/units ... are explored.

STUDENT RESULTS

provided time : 5h
average time spent: 7h
FAÇADE DESIGN

WHAT

Students make a 2-dimensional façade design using AutoCAD tools (grid, rotate, mirror, offset ...) and a built-in proportion system. This system is based upon historically important geometrical series like the golden section and the ideas of Le Corbusier in his Modulor and Les Tracés Régulateurs. It is implemented on top of AutoCAD and, in combination with some existing commands, gathered in pull down menus for easy use by the students. Choices made by students are advised and adjusted by the program to fit these choices into the logic of the proportion system. This creates order into the composition. The student’s design process has to be documented by way of a series of slides that, ultimately, are combined in a slide show.

WHY

At the moment, the computer is widely used to model (already existing) designs, but rarely during the first design stages of rough sketching and exploring possibilities. With the façade tool, students are forced to fill this void. Next to practising graphical tools that provide modulation and symmetry, students realise that a computer can, instead of hampering the design process, be of great assistance. The software module and according menus that we developed provide a first glance at the customisation possibilities of AutoCAD. Finally, students learn to use slides and slide scripts for presentation purposes.

STUDENT RESULTS

provided time within student’s agenda: 5h
average time spent: 9,5h

documentation of the design process by an number of slides, based on the golden section, dutch commentaries are omitted (Wim Suffeleers, 1996)
The extraction exercise consists of two major parts. Firstly, students extract attributes of newly placed furniture in a library room and export it into an external text file or spreadsheet program. The features of such a spreadsheet program are explored. Secondly, in the other direction, numerical data residing in an external database are linked to graphical entities in the AutoCAD drawing: a list of books is linked with the ‘books’ entities in the drawing. Small query orders are made using these alphanumerical and graphical data. Finally, students are invited to produce a short essay on applications of this technique in architecture and urban design.

### Why

Showing the potential benefits of an 'intelligent' system where graphical and alphanumerical data can be linked, is the main pedagogical goal of this exercise. Automatic generation of the bill of quantities and specifications, performing all kinds of tests on the model (energy, light, stability ...), deduction of production orders ... are applications based on this important linking. In the meantime, however, students get the opportunity to explore spreadsheets and databases.

### Student Results

Provided time within agenda: 2.5h
Average time spent: within the limits of the time schedule

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*eCAADe 1996 - PDF-Proceedings (conversion 2000)*

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Library room, extraction template and extracted text file (Jan De Greef 1996)
Solving a design problem often means looking for a solution at an elementary level and gradually refine and give it a concrete form. The computer can provide this refinement automatically by using a modular building system with few different building elements. In particular, students are asked to realise a 3-dimensional design using predefined container elements drawn at different levels of detail, in combination with some elementary editing functions (inserting and deleting wall panels, windows, railings ...). The aim is to conceive a weekend residence for a person with a very specific profile, for example an astrologer or a benji jumper. During the design phase, students can easily switch between two different levels of abstraction.

Realising the strength of computer aided substitution during the design process is the main pedagogical goal of this exercise. Concretely, students learn to position existing 3-dimensional elements in space and to manipulate topics as view and user coordinate system. The organisation of the graphical screen in appropriate viewports is another aspect. Next, the provided software routines are to be placed in pull-down and icon menu's. Hence, a first acquaintance with customisation of a package to the user needs is obtained.

provided time within agenda: 5h
average time spent: 7.5h
SURFACE MODELLING

**WHAT**

In the previous exercise, positioning existing entities in space was the acquired knowledge. The next logical step is to model 3-dimensional entities. After an introduction concerning different modelling techniques (wire frame, surface modelling, solid modelling) we provide the students with a simplified non digital model of an existing building. Until now this was a part of the Leicester University Engineering building by Stirling. A surface model has to be deducted. General drawing settings and layer organisation are chosen by the students.

**WHY**

The different ways to model a 3-dimensional entity are explored. Concerning a surface model, the step from a 2D element with a thickness to real 3D faces, polygon meshes and 3D objects is taken. Students learn the principle of hidden lines elimination and other more advanced rendering techniques. The previous acquainted knowledge about viewing a 3D object and wandering around in space is further trained.

Thus, we provide the basics for easy modelling of the projects that students realise in the design studios at our department.

**STUDENT RESULTS**

provided time: 2.5h
average time spent: 4h
FRACTAL TREE

**WHAT**

Beside its mathematical definition, a fractal can be defined as a geometrical structure with a high degree of self-similarity obtained by a recursive procedure. Students first get a general introduction in the fascinating world of fractals. Secondly, the principles of the Autolisp programming language are explained. Finally, they are invited to explore and complete an unfinished Autolisp program that describes the generation of a 2D fractal tree. Or they can produce their own fractal object, based on the given routine and getting fractal inspiration in a provided reader about the subject.

**WHY**

Apart from learning about fractals and their potential use in architecture, some additional computer and Autocad skills are trained. Programming recursion in Autolisp and programming in general is the first one. Linking such an external routine to an Autocad drawing is the next step. The advantages for further customisation of such linking are pointed out. The underlying structure of AutoCAD entities and commands becomes clear. It goes without saying that a full understanding and knowing of Autolisp can not be obtained in one single afternoon, this exercise is merely meant as an introduction: students learn about Autolisp’s existence and are invited to explore it further for their own needs.

**STUDENT RESULTS**

provided time within agenda: 2.5h
average time spent: within the limits of the time schedule
SOLID MODELLING

WHAT
In the second year of their architectural curriculum, students have to make a global analysis of a well-known house. At that time, all representative drawings were made by hand. In contrast to this representation with pencil and paper, we ask them now to make a digital model of that same building. First of all, a strong simplification of the chosen project is needed. This purged version is modelled with AutoCAD’s solid modeller AME. The student himself has to find out the most practical drawing organisation. Additionally, some good views and cross sections are generated and presented within the standard frame and colophon. These ready-to-print documents are realised using AutoCAD’s paper space utility.

WHY
Having explored surface modelling in a previous stage of the course, solid modelling is the next logical step. Since students model existing buildings (not designed to be modelled digitally), the possibilities as well as the disadvantages of the technique become quite clear. Stress is laid upon internal organisation of the drawing and the importance of deciding in advance at which level of detail they want to represent the building. Moreover, the great benefit of splitting the modelling and representation phase (in contrast to traditional drawings) becomes clear by forcing the students to hand in printable documents.

STUDENT RESULTS
provided time within agenda: 5h
average time spent: 16h
LIGHTING

WHAT

Depending on the phase of the design process, a computer can provide the architect with interesting facts and data concerning his building model. The same test (for example calculation of heat loss) can be different from one stage to another: the rude and elementary application of rules on the first design sketches versus very accurate computations on the final design. Students use a very rudimentary program to test the illumination level in one single room, meant to be used during the early stages of the design. Only artificial light is taken into account. The assignment consists of modelling a lighting installation (choice of light sources and layout) for a particular classroom. While placing lights within the AutoCAD model of the room, a fast test of the required light level can be performed in an interactive way i.e. without leaving the graphical application.

WHY

Being engineers as well as architects, we considered it important to show the integration of a graphical representation of a design and at that moment relevant tests. The latter provides the architect with information he could never easily produce by hand, and influences further design decisions. The choice for the computation of illumination levels was merely a practical one, having the program available at our department as a result of previous research. It is obvious that in the ideal situation all these tests can be performed upon the same model, whereas at the moment every software developer constructs its own model of the building environment.

STUDENT RESULTS

provided time within agenda: 2.5h
average time spent: within the limits of the time schedule
**PRESSURE LINES IN AN ARC**

**WHAT**
A software program has been developed to compute the centre of pressure line in arcs based on the graphical technique. Implemented on top of AutoCAD, it gives the designer the possibility to design and check the stability of arcs in an interactive way. Several arc configurations can be easily checked while being in the design stage of a project. In this way, it is a tool easy at hand to help the designer to make the right decisions while conceiving. The program can do several things, going from the calculation of the two extreme centre of pressure lines within given constraints, to a proposal for the ideal geometry of an arc starting from the computed centre of pressure line. The nice thing about arcs is, that as soon as you find any feasible centre of pressure line, you can be sure that the arc will act upon it and be stable. During this exercise, students are invited to design a configuration of arcs and explore its possibilities in an intelligent manner. The program (until now only worked out for planar arches) calculates automatically the dead weight of the arc. External forces can be added in an interactive way.

**WHY**
As with the previous exercise, showing the students the possibilities for integration of drafting and calculating is the main goal of this exercise.

**STUDENT RESULTS**
provided time within agenda: 2.5h
average time spent: within the limits of the time schedule

*the graphostatic principle to determine the centre of pressure line and some student experiments (Toon Van Borm 1995, Greet Houben 1995)*
Order a complete set of eCAADe Proceedings (1983 - 2000) on CD-Rom!

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