University CAAD-education for architectural students

-a report on the realisation of a use-oriented computer education
at the bauhaus university weimar.

by Dirk Donath[1]

1. Abstract

Practically no other field of human creativity is evolving as fast and innovatively as the development and integration of the computer into every possible area imaginable. The computer has today become a natural tool in the fields of architecture and space-planning. The changing form of professional practice due to the increasing application of computer-assisted work techniques results in the need, currently being addressed in the education of future architects and town planners, to bring these new mediums into the realm between architecture - art - and building - science.

2. A fundamental grounding in computer awareness

In the light of current discussions about inter-disciplinary education and integrated courses of study, the collaboration between different subject and scientific study areas has become more important than ever before. Through the existence of an Institute for Applied Computer Science, for Architecture and Town and Regional Planning, for Building Engineering and for Design, the University in Weimar is in a good position to address these requirements.

The students should be made capable of *using computers* as a working tool, instead of just being able to *operate a computer.* Building on this fundamental principle, not just the use, but also the processes, principles and models of the uses of computers in architecture, town and regional planning are taught.

The intake of knowledge and familiarisation with the computer is a process which, due to its relative alienation from daily life, can in no way be artificially speeded up. With this in mind, probably the only way to achieve a higher quality of intake is to ensure **continual contact with "computer" as a medium** from day one onwards.

The basic aim is to develop a teaching concept that links the individual subject areas of architecture with their current developments in computer technology, that is to say, an **integrated course content** for all courses of studies, taught, in part, in inter-disciplinary teaching sessions. The emphasis is laid on integrated course content, teaching sessions with students from different study courses, as well as those monitored by staff from different subject areas.

Principal among the factors to be taken into account are:

- the ever growing number of students;
- the almost constant number of students really interested or capable in the field of Informatics;
- the differing interaction architectural students and informatic students have with CAAD;
- the increasing use of computers in practice and resulting minimum level of CAAD proficiency expected from graduates.

The hub from which an integrated course content is derived, is computer-supported planning and design with special emphasis on the following areas:

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[1] Dirk Donath, Prof. Dr. Ing., Chair for "Informatik in der Architektur und Raumplanung" (Computers in architecture and planning) at the Bauhaus University Weimar

- the inclusion of current developments in technology (hardware) and computer systems (software)
- the influence current developments in computer-supported systems have upon the different subject areas of architecture and town and regional planning.
- the conception and realisation of the application of computers in response to demands from the individual subject areas.

3. The necessity of a differentiated course content

Experience show that, during the course of studies, three major target groups develop:

Target group **A**: **The classic architect**

ó the designing, planning architect, who possesses a basic knowledge of CAAD as a tool.

Target group **B**: **The CAAD proficient architect; “Insider“**

ó architects who, in the process of planning will become CAAD specialists;

Target group **C**: **The CAAD specialised architect; “Freak“**

ó architects who will become involved in the conception and further development of CAAD systems.

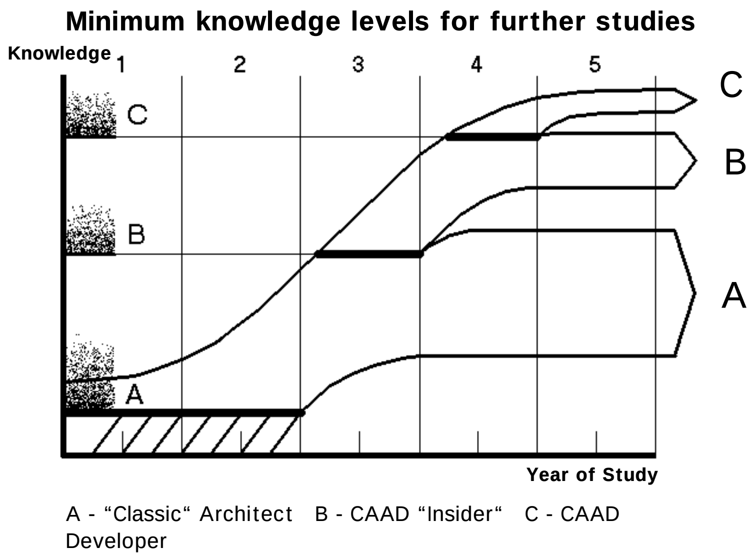

Figure 1 Target groups and course structure

It is a fundamental principle of the university to address the education of all three target groups. In harmony with the aforementioned factors, the importance of a proficiency-graded system of differentiated course content becomes clear. The knowledge level of each student should be the only judgement criteria for those wishing to further their studies.

Within each target group a clearly pre-defined **minimum knowledge level** must be reached in accordance with their corresponding course of study. The actual **minimum levels** for each target group are defined by the expected sphere of activity in professional practice and the corresponding proficiency levels demanded:

the “classic“ architect:

ó an awareness of the breadth and limits of CAAD application;

ó an understanding of the principles and functional aspects of CAAD;

ó fundamental operation of different systems, the diverser, the better

ó knowledge of the different application areas within the planning process

ó basic awareness of development directions

the CAAD- proficient architect; “Insider“:

ó basic knowledge as for the **“classic“ architect**;

ó a ‘good’ to ‘very good’ operational knowledge of several CAAD systems;

ó deeper knowledge of the structures and background principles of CAAD systems;

ó basic proficiency in special application areas.

ó awareness of the organisation and connections between the individual parts of the overall architectural planning process –CAAD management;

ó detailed **“**inside-out“ knowledge of a favourite application area.

the CAAD specialised architect; “Freak“:

ó basic knowledge as for both the preceding with the exception of the **“inside out“** knowledge;

ó overall knowledge of general and applied informatics**;**

ó knowledge of the background of CAAD systems seen from the viewpoint of applied informatics:

ó knowledge of fundamental trends in CAAD software development

The course content, with respect to target group C, no longer corresponds to that of **“**classic“ architectural studies. The need for an integrated course of study – computer engineering with special emphasis on building or town planning should be seriously considered.

4. Principles of realisation

The course content is split in two in accordance with the university’s general study plan organisation:

“**Grundstudium**“ (Foundation studies) introduces basic program systems and familiarises students with computer usage. The aim is to imbue an elementary knowledge, providing a fundamental user-oriented computer proficiency. It is foreseeable that in the future such basic knowledge will become a part of school education.

- In “**Hauptstudium**“ (Core and Diploma studies) a subject-oriented grounding and background knowledge is taught which, through the use of project-related examples and application, is discussed and reflected upon. As befitting a high-quality course, it attempts to integrate research and development tasks directly into the course content.

These are examined and investigated through their incorporation in student projects.

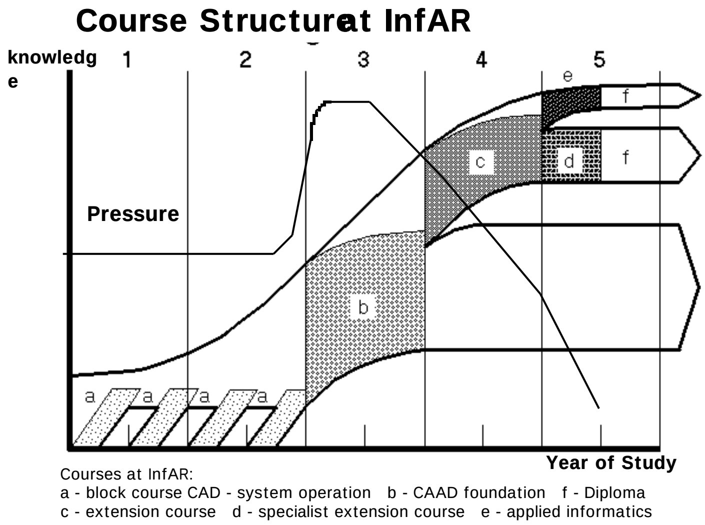

Figure 2 Organisation of teaching structure for each target group

The **pressure** on the student is directly related to the chosen level of studies:

1. A minimum level of knowledge is attainable through a series of clearly- formulated block teaching sessions (crash-courses or similar).
2. a subject related grounding is provided by mandatory semester courses (CAAD foundation course)
3. For students in target groups B and C, a two semester CAAD extension course is required to achieve the minimum standard for this level.
4. Candidates for target group B can extend their knowledge in the 9th semester through a specialist courses, whereby emphasis is on the solution of practice-related CAAD management tasks.
5. For candidates in target group C or those undertaking specialist courses, the semester course content is almost exclusively informatic.
6. Students in target groups B and C can also choose to write their Diploma at the chair InfAR as culmination of their studies.

5. Current teaching situation at the Faculty of Architecture, Town and Regional Planning, Bauhaus University Weimar

In the context of current study reforms integrated project work is taking increasing importance. The chair InfAR is strongly in favour of this form of study, and organises its study options accordingly (see Tab.1).

The current study options are organised as a ‘step-by-step’ building block system of increasing complexity as follows: (SWS = hours per semester week)

- optional block courses for basic knowledge (2 SWS, Seminar)
- mandatory CAAD grounding as part of core studies (2 SWS, Lecture / 2 SWS, Seminar)
- a selection of optional extended knowledge courses for further investigation of aspects of computer usage (4 SWS, Lecture and Seminar)
- Semester projects for detailed investigation of the use of computers as a medium, through the vehicle of a relevant design problem
- joint consultation and integration of project work from the design faculties

Integrated within these course provisions are those of informatic students who, over and above this basic level, also study the detailed technical programming concepts. The content is, however, directly related to the concerns of the architectural and town planning courses.

PC-Basics
Basic knowledge: General hardware and software systems

CAD system operation
Basic proficiency: Operation of a chosen CAD system

GRUNDSTUDIUM

HAUPTSTUDIUM

CAAD-Foundation
Fundamentals of computer usage in architecture,
enabling the assessment of architecture specific programs

CAAD- Extension course

VR supported architectural design From the idea to the 3D-model: VR supported form finding and Visualising an architectural idea.	**Computer supported Building Survey, Modelling and Presentation** Methods and procedures, practical experience, CAD-processing	**Computer-supported techniques in town and regional planning** creation of digital maps, Contour-modelling, urban form, Facility management	**Semester project** carrying out of an architectural project investigating the application of computer techniques

Interdisciplinary project groups / Design assignments / Scientific seminar projects / Diploma

Tab. 1: Course provisions at the chair InfAR for architectural and town planning education

Some images will give an impression of the direct transfer of theory into practice in the study course.

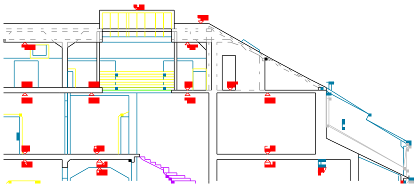

Figure 3 optional extension course: Digital building survey: van de Velde-Bau, detail

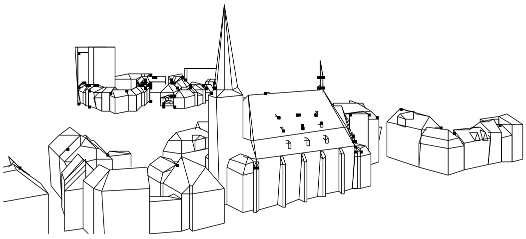

Figure 4 optional extension course: Block model of Weimar town centre

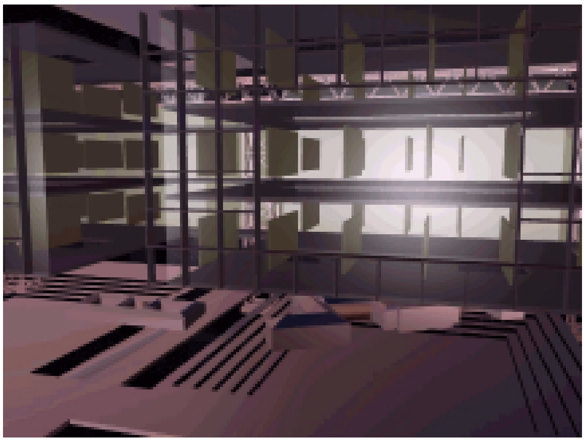

Figure 5 optional extension course:Semester project: "Making the invisible visible (Hanke, Müller)

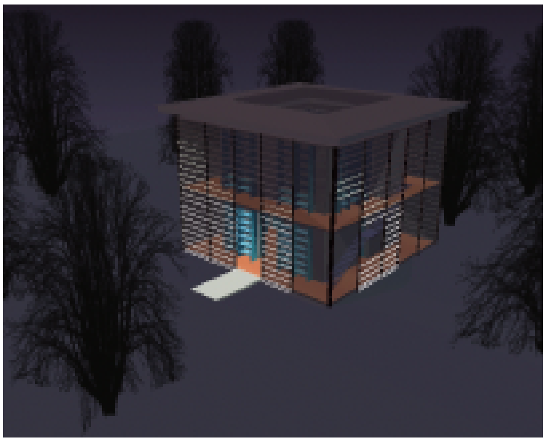

Figure 6 optional extension course:Semester project: "Making the invisible visible" (Peter Bringt)

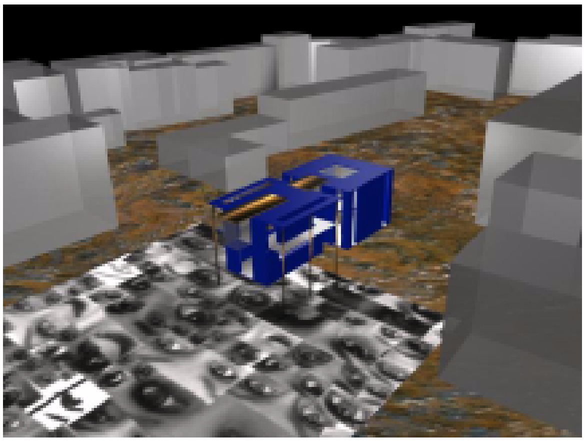

Figure 7 optional extension course:Semester project: "Making the invisible visible"(Andrea Walz)

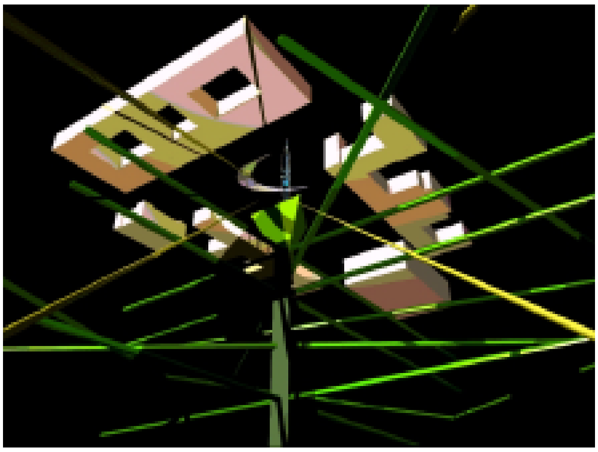

Figure 8 optional extension course:Semester project: "Making the invisible visible"(Thomas Bachmann)

Due to the limited amount of actual study time in the form of lectures and seminars, the courses primarily bring across a general overview and understanding. It is therefore important that alongside coming to grips with the computer as part of project work, the student consolidates his or her capabilities both in content and through practice.

The majority of courses are in the form of lectures and exercises spread over the semester. It has, however, become clear that this is not necessarily the most practicable form. The actual work content of the course is difficult both to achieve and to fully comprehend within the fixed study periods of two times 1 _ hours a week. To compensate for this, much can be achieved through project work, which functions just as little on a ‘one-and-a-half-hour’ basis. The lectures relate directly to the seminar exercises and are as such directly connected to one another.

Lectures and seminars are primarily undertaken in a specially equipped computer pool (fully networked with 19 PC graphics-workstations (80586, 120 Mhz, 4,3 GByte), 2 Macintosh computers, 4 UNIX workstations, one SGI Crimson with VR equipment and high-quality graphic peripherals). Software at hand covers a broad spectrum of current and powerful CAAD and AVA systems, special applications (Geographical Information Systems, vectorisation systems, digital tachymetry, DTP, word processing, animation, multi-media) and development tools. On principle, the students can use the computer pool including the peripherals round the clock, and thereby have enough free space for their own work. For complex and specialised work, integrated architectural and engineering software is available for use in the high qualified UNIX pool at the institute of applied computer science.

Also worth mentioning are current problems in relation to realisation of the teaching concept:

the high level of preparation required and ‘coaching’ involved for seminars (max. 10 workstations per assistant);

the nerve-racking hardware and software maintenance task (particularly where multiple programs are used within a single network);

and

the extreme varied user proficiency.

6. A interdisciplinary student project: Virtual Reality Aided Architectural Design

This student project begun by setting up a multidisciplinary project group in autumn 1994. Four different disciplines are involved in the project: computer science, architecture, product design and psychology.

At first it was necessary to bring together the multiple views on virtual reality. The main topics of the discussion were:

· investigations about real and virtual space including the coherencies

· forms of communication and recognition in virtual worlds

· navigation in virtual space(s)

· interaction with virtual objects

· information displaying

· questions about ethics and social responsibility

Although the results of this discussion are not that spectacular this kind of approach was necessary for establishing a workable group. The different and individual views and attitudes were expressed via 3D-modeling and animation tools (non-VR). Some problems are still unresolved, such as realistic vs. symbolic information displaying and circumstances in which a private sphere is needed, to mention a few.

The discussion and the results are documented in (Briefe an Vradmin 1995) and (www.uni-weimar.de/iar).

To establish a more precise idea of the possibilities and limitations of VR, two additional sub-projects were set up: the „platform“ project and the „voxDesign“ project.

With particular regard to usability tests and other methods of experimental psychology and human-computer interface design it is necessary to provide an appropriate physical environment. To fulfil the desire of a large interacting room the main design goal of the „**platform-project**“ was to provide an almost unconstrained physical space of about 4 x 4 x 2.5 meters. Within this space there are no obstructions to the movement of the actor.

The other goal was to integrate all the technical equipment needed for the VR application. The platform should can be used for both public and research presentations/tests and for system development too. The hmd and the tracker cables are lead through a rod-like construction. Integrated into the whole system is all the equipment needed for demonstrations and development. When used for presentations, the audience can follow the interaction process of the virtual world via two additional monitors and an optional large screen.

The software solution „**voxDesign**“ was developed with students of applied computer science and works together with the physical environment „platform“. voxDesign is implemented in C/C++ based on the SGI Graphics Library GL.

The main goals of voxDesign are:

- Realising a simple (to use and to implement/modify) virtual reality aided design (VRAD) system for the early phases of the architectural design process.
- Providing an experimental system for studying human - computer interfaces in virtual worlds.
- Using the system in architectural and design education.
- Transferring a VR application from the laboratory to real usage.
- Public presentation of the possibilities and limitations of virtual reality.

Figure 9 working on the „platform“

7. CAAD-Extension course: VR supported architectural design: From the idea to the 3D-model

It is still not usual practice at European universities to confront students with VR techniques in practice. We decided to provide such an opportunity to about a dozen of graduate students in architecture.

They had to solve an architectural design task in virtual space. The two main topics for the students were to describe their design thought with voxDesign and to reflect the process of the design variants using this new technology. One side-effect of this course for us was the possibility of a first set of usability tests.

The given task was not that spectacular and actually not that important: to design a personal (individual) virtual student room with all communicational and housing structures only in the very early phases of the design process. The complete design was to take place in virtual space (the voxel room). For presentation purposes the students were allowed to edit the model or views of the model with external programs, although the design idea itself had to be developed in the voxel space.

The course was offered to senior and graduate students only. Our intention was to give them a new tool to express their design ideas, not to teach them the basics of architectural design.

Before entering the course most of our students had the following skills and knowledge:

- knowledge of the basics of computer-aided architectural design (caad)
- experience in architectural design using the traditional techniques and tools
- no knowledge of or experience with virtual reality
- experience in setting up architectural models
- readiness to explore a new terrain

One main goal was to give the students a feeling of what virtual reality can be. After finishing the course we wanted the students to be able to distinguish between the facts and fiction, to know the possibilities and limitations of this technique, and to estimate the influence on social life and especially on their own profession.

For these reasons the course covered the following topics, in addition to practical work with the system:

- the fundamentals of virtual reality
- the history of computer graphics and VR
- basics in using workstations and local and wide area networks
- basics in digital model and picture handling
- the social and psychological impact of virtual reality now and in the future
- questions of perception and cognition using VR techniques
- some philosophical aspects of (virtual) reality (esp. Radical constructivism)
- some aspects of the theory of media

For more details on this course see http://www.uni-weimar.de/vradmin/Couses/Course01/.

The discussions about the general and theoretical subjects were very fruitful for both, the staff and the students. Thinking beyond one’s own professional borders broadens one’s field of view, not only in the context of virtual reality.

The practical sessions took place in our [atelier, virtual] room. It is a 40 m_ room with two workstations, two personal computers and the platform, not to mention the coffee maker, a lot of literature, records and CD´s, and presentation equipment with 24 hours room and Internet access, a conference table and a lot of ashtrays. For special presentations a video-beamer was connected to the system so the inside of the virtual space could be displayed on a 4x3 m_ screen; this was very impressive. For the auditory the actor acted inside the virtual space.

The results of the design task were very different from traditional techniques (see student work results). In a very different way the students tried to use and explore the new medium. Most of them left pure real-world metaphors (like chair, table, wardrobe) and „played out“ the other opportunities and properties of virtual space like the absence of gravity or static laws.

Some further results in brief:

- the Stylus exhibited very good usability including the twist mode
- 16 colours are enough for the design task
- using sound as a design environment was very welcome
- the most spectacular effect was to „experience“ a virtual structure by just going around them
- the students confirmed our assumed voxel size as fine enough for this phase of the architectural design process
- primitive CAD functions were missed, like line, wall, circle
- the selectable value for the field of view is very dependent on the individual (between 30 and 100 degrees)
- the estimated duration time by the student was shorter every time than the real time
- most of the students were immersed (or at least involved) in the virtual voxel space during their design sessions
- using a pen metaphor as a pointing device seemed to be the right decision; the students associated it with sketching
- there should be more depth cues in virtual space, like fog (aerial pollution), reference objects, well placed light sources, perhaps spatial sound applied to the objects and the space

To give a better impression of this course here are examples of selected student work (1996):

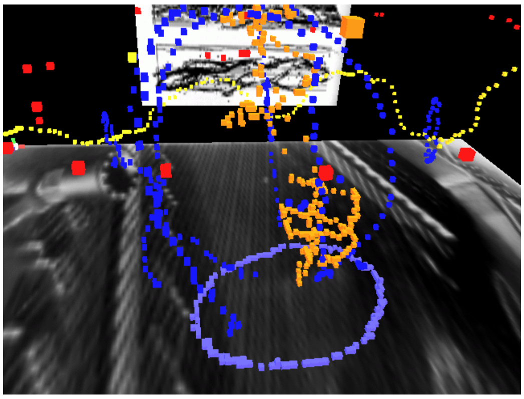

Figure 10 Student design in virtual space (example: „music/ virtual exhibition“ Summer 96)

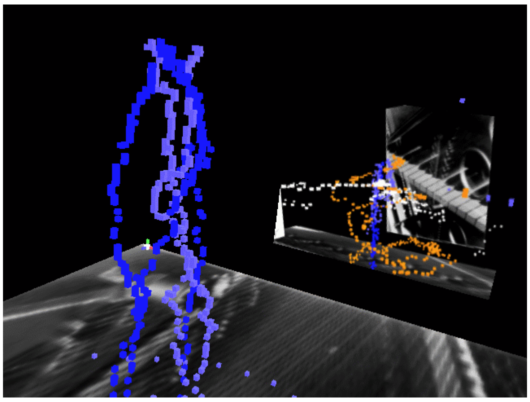

Figure 11 Student design in virtual space (example: „music/ virtual exhibition“ Summer 96)

8. Existing responses – Future prospects

As future CAAD systems increasingly enable a comprehensive consideration of different and integrated planning aspects, the computer-related abilities of the architect will have a direct influence on his competitiveness in the market place. The teaching content is conceived with this in mind. CAAD education has attained a firm position in the education of architectural and town planning students at the Bauhaus University. This manifests itself in:

the high demand on the computer technology available to students;

the continuous, almost 100 per cent seminar participation in the CAAD foundation course;

the high interest levels in the specialised courses, and

the resonance of the results of computer-supported student work in other study course at the Bauhaus University.

In architectural practice, an extreme demand for qualified architects with active computer proficiency has been shown to exist. Inquiries come in constantly for trainees and graduates with such skills. Also clear is the necessity of different levels of existing knowledge, coming as much from planning offices (by far the biggest), as from constant demand from the side of software houses and developers.

9. Acknowledgements

Our current teaching work would be impossible without the great efforts of all the members of the chair of InfAR, especially of Marion Schmitt, Claudia Ott, Holger Regenbrecht and Frank Petzold. Jens Knuepfer turned our ideas into a real and working computer equipment, thank you. Thanks also to Johannes Hillebrand for his contribution to this paper.

10. Literature

„Briefe an vradmin@“ internal publication at the Bauhaus University Weimar, 1995

Bauhaus University Weimar WWW-home-page http://www.uni-weimar.de

Chair of CAAD and Architecture: WWW-home-page http://www.uni-weimar.de/iar

Weimar, August 1996

Index of Pictures