

**The Conception of Education in CAD  
for Architects and Planners  
at the University of Kaiserslautern**

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## 1. Introduction

In February 1990 the University of Kaiserslautern founded the new teaching and research department "Computer-Aided Design and Construction in Environmental Planning and Architecture". Unlike other German universities, the speciality of the new teaching department is in the common education of architects and environmental planners (including urban planning), so that a wide range of computer systems is at their disposal: computer-aided architectural design systems just as geographic information systems, picture processing or information systems to support urban planning etc. No other German university disposes of this kind of common education in a single teaching department.

The following aspects will be discussed:

- The general concept of education in three dimensions, viz. a dimension of application concerning architecture and urban planning, a dimension of technical features concerning computer applications and a dimension of critical judgement.
- Contents of education and teaching concept including examples and students' resonance (see appendix).
- Research fields in urban planning and architecture which are necessary for a practical-oriented education concept.
- Experience with the educational background furnished by the students of architecture and environmental planning and general consequences for the teaching concept.

To meet future requirements of computer staffs in urban planning and architecture, the University of Kaiserslautern founded the new teaching and research department. Thus, the teaching situation has been adapted to future practical needs with particular focusing on the situation in the planning boards of public administration. Compared to other German universities, the new research department in architecture and urban planning (in Kaiserslautern named as spatial and environmental planning) is a novelty. Mainly the integrated management of both architecture and urban planning is advantageous, as computer program systems must be provided for both education courses. If each education course would exist alone with its specific software systems, the number of the offered systems would be considerably smaller. So, this situation is obviously different to that of other universities.

## 2. Teaching

Due to the actual needs in architectural and planners' practice, teaching in the new department concentrates on computer-aided design techniques or construction methods in architecture and on applications and methodical development of computer-aided information systems in urban/environmental planning.

The general teaching concept consists of three dimensions:

1. a functional dimension in which special architectural or planning problems are solved by computer technology;

2. a technical dimension dealing with the potentialities of computer technology leading to new software developments;
3. a dimension of critical review examining the constraints of computer technology as a subject in the architectural and planning field.

### **Teaching Concept**

Realizing the teaching concept, however, one must take into account the fact that the use of computers is a new ground for many students of architecture and urban/environmental planning. Teaching must focus on instructing students in the basic skills using computer programs, i.e. the students must learn a matter-of-course use of the computer. In addition to the simple handling skills, instruction provides knowledge about the subsequent and implemented processes executed within the computer systems; this must take into account to the current methods and design theories being familiar to architects and urban planners.

In order to come up to all these requirements under scientific aspects, it is reasonable to subdivide instruction into three stages:

In a first stage, handling skills of computer systems are to be learned by applying one model CAD-configuration and by solving a simple design task. Besides, lectures are focussing on more theoretical aspects of the matter.

In a second stage, basic knowledge is to be extended on different systems so that students are enabled to evaluate the efficiency of software systems and their implementation on different hardware systems. This is to be realized by solving more complex design tasks and by making higher demands on the quality of visual representation. In addition to that, instruction includes some basic programming knowledge of so-called user-oriented programming languages, such as UPL, which has a syntax similar to that of PASCAL, and which is the complementary language to "Personal Designer/microCADDs-GCD" (see below).

In a third stage, leaving behind the simple application of programs, students are motivated to develop on their own computer programs for special architectural or planning problems. At the same time, students have to analyze the merits and shortcomings of the application of architectural and urban planning software systems, e.g. by reflecting on theoretical aspects of architecture and computer aided design or in relation to problems like data protection or a lack of acceptance when recording data in the field of urban planning.

The students' acceptance of this education concept is currently high. We hope that such a three-stage teaching concept will come up to the future trends, when there will be more beginners with basic programming knowledge.

### **Teaching Contents**

Even if teaching contents relating to computer knowledge have to be dealt separately for urban planning students and students of architecture, the most essential contents can be summed up in three points:

- Teaching of basic knowledge: It mainly deals with the computer aided design software for architecture, with information systems in urban planning as well as with hardware knowledge as the basic requirements for programming. In addition to that, essential mathematical knowledge must be taught focusing on the comprehensive aspects as a kind of mathematics "put

into words". The knowledge in formal and abstract mathematics may prove to be necessary later, if students become interested in developing computer programs or in knowledge-based design systems.

- Data gathering, information integration, analysis and evaluation of spatial data. Essentially, this concerns the several levels of the spatial planning process by using computer technology. The field of urban planning is clearly focusing on special applications of "Geographic Information Systems" (GIS) like vector processing, raster processing and graphical hybrid processing. In architecture and in urban planning, recordings of the current status and analyses involve working in three spatial dimensions. So, other methods, e.g. computer-aided registering by architectural photogrammetry or an analysis of form and space using computer-aided animation methods play an important role.
- Development and representation of design projects: The intent of this point is to get a good handling skill of specific CAD-functionalities - beyond the basic functions of computer-aided graphic systems. This will mainly be useful for architectural modeling but equally for the plans developed in urban planning (as site plans/development plans, general land use plans, regional plans). An important aspect is the availability of hardware and software components in order to produce visual images. Those models are playing an ever growing role in architectural and planning competitions and must already be used in education.

### 3. Software Systems at Disposal

At present, the teaching department for using computers in architecture and environmental/urban planning has at its disposal the following software systems permitting to solve most of the tasks mentioned above:

- ARC/INFO** A vector-oriented geographic information system used to manipulate geographic data in digital form with a incorporated relational database management system. In our teaching department, ARCIWO is working on PCs as, well as on workstations. (Developer: ESRI, Redlands CA/JUSA)
- ERDAS** A raster-oriented geographic information system, providing picture processing and raster analysis. ERDAS is working on a PC and can be linked with the ARC/INFO data structures. (Developer: ERDAS, Atlanta/USA)
- GCD** The software system microCADDs Geometric Construction and Detailing (GCD), also known as "Personal Designer". This is a construction program working on a PC-level using surface modeling of spatial objects. It is not a constraint to a specific variety of users. Emphasis must be placed on the user-oriented programming language UPL, whose vocabulary is rich, and which provides GCD a very large flexibility in applications. (Developer: Computervision/Prime, Bedford Mass./USA)
- MINIKAT** A simple cartographic program for PCs. (Developer: AED-Süd, Meckenheim/Germany)
- PA** The volume-oriented CAAD-system Personal Architect (PA) focusing on the cubic shapes of rooms in buildings. Specific architectural characteristics are automatically generated by special so-called "technology files" and symbol libraries providing about 30,000 architectural details in storage. An interface to GCD enables even more realistic visual images of the

architectural design. (Developer: KEOPS, Marseille/France)

**PROCAD** A CAD package mainly for civil engineering based on a constructional approach (focusing on wall elements) relating to a quasi volumetric based storage model. (Developer: mb Programme, Hameln/Germany)

**SPIRIT** A surface-oriented CAD-system for three-dimensional architectural objects working on a PC-level including the ability to produce realistic computer graphics. (Developer: Soft-tech, Neustadt a.d.W./Germany)

In future, the department expects a shift towards to more workstation applications. Whereas ARC/IN-FOGIS already come up to this trend in the field of urban and environmental planning, architecture still needs great efforts to provide efficient computer graphics for architectural design models (high-performance rendering, animation, multimedia applications and so on).

After having finished the networking of the university campus and the communication systems supporting the infrastructure of the university, the new teaching department intends to increase the use of systems and peripheric equipments provided by the Regional Computer Center of the University of Kaiserslautern. This applies to SICAD mainly, a system often used in urban planning. It also applies to large-format scanner/rasterplotter configurations including mass memories; this equipment which will be available in the near future.

#### 4. Research

The teaching concept and contents aim to satisfy the requirements of the architectural and urban planning practice. The research strives towards the same objective. There follows a list of topical research projects, some of this will be tackled soon, while some have already started.

##### Research Projects in Urban/Environmental Planning

In the urban and environmental planning field, the new teaching department places emphasis on the following projects involving the local government level of planning:

1. Computer-aided design of development plans: The development plans have the major impact on planning decisions because they have the legal force, but computer technology is still in its infancy in this field. Graphic software producing development plans according to the regulations of development plan symbols are not a problem. Lacking legal unity is a serious problem, and this is related to other problems like a shortage of maps provided by the automated mapping concept for land property (ALK=Automatisierte Liegenschaftskarte) or because of the uncertainties in assessment and the computer processing. Research in this field is to make in cooperation with local government practice and involves the exact knowledge of local government organization.
2. Planning systems and environmental information systems: Similar to the development plans, computer application is also in its infancy. Whereas there already exist the computer applications on the level of regional or general land use plans which represent small scale plans, large scale development plans are still lacking. There is a need for such systems, e.g. when development plans are used for an environmental impact assessment test in order to minimize the detrimental impact on environment in this area. Therefore, environmental data are needed on a large scale.

3. The "Baugesetzbuch" (the German Building Law) directs an appropriate and just consideration of all official and private concerns. But, this consideration is often neglected, as we have a lot of development plans that, after having passed into effect, are stopped by a so-called "Normenkontrollverfahren" (action to test the constitutionality of law). Past experience has shown that the cause for incorrect consideration is not seldom lacking expert knowledge. Therefore the idea is formed to support decisions by an expert system. Research will focus on the integration of a knowledge-based expert system into the practical urban planning process. In our department, we cooperate with the computer science department of the University of Kaiserslautern to create a first basic concept and to test an implementation for the noise level problem within urban planning.
4. Computer graphics representing urban sites is not a new topic of research, of course, but it offers new insights by developments in multi-media and hyper-media methods developed most recently. This field will play a very important part in urban planning research in future. Therefore, research projects will have to focus on that topic.
5. Aerial photographs or satellite aided methods do not register changes within developing urban areas very efficiently as important developments in land use may occur within built-up areas as well. Therefore, it is necessary to register the "real -land-use " data not only by aerial photographs, but also with the additional data collected on site to build up the spatial or landscape observation systems. These systems do not only provide important information for the new general land use plans (planned to be realized all over the Federal Republic of Germany), but also help to discover and to observe the creeping change of land use within built-up areas or even urban districts. Building permissions can provide information for analysis, being available in a database.
6. In order to put up a general land use plan, complex assessment methods must be used. There are only few computer-aided methods in this field so that we will focus on that subject in near future. Complex assessment means that, firstly, every site must be considered individually (e.g. when investigating sites designated for certain infrastructure institutions like refuse incinerators). Then, the information about land use suitability of certain areas within built-up and free areas, and the individual site conditions must be put together by a complex assessment method.

### **Research Fields in Architecture**

In this field, research focuses on the following topics:

1. For many years, computer graphics have been the center of computer-aided design in architecture. The construction of architectural models has not played a role up to now, because some specific techniques for computer-aided model construction were lacking. So, the hollow spaces or "filligran" structures could not be produced. During the last few years, the stereolithography method has been developed in form of an efficient computer-aided construction kit method, based on photopolymer chemistry and laser technology. In our research department, we have just finished a first research project focusing on that topic.
2. Whereas CAD-systems have been used to support the construction of new buildings for some time, computer technology has not yet focused on old buildings. Research projects will place emphasis on data capture and on the subsequent data analysis resulting e.g. in building reconstruction; multimedia and hypermedia methods will help to realize this project.

3. Computer graphics are often admired because of their extraordinary appearance. The beholder, however, gazing at the graphic object in wonder, forgets that it is the aesthetics of computer generated images that he is marvelling at. But those graphic images, sometimes called computer art, have little to do with the aesthetics of the building realized afterwards. Therefore it seems absolutely necessary to think about the relation between the images designed by CAD and real architectural objects on an aesthetic level.
4. As CAD-experts with a sense for the theory of architecture remarked recently, a theoretical consideration of CAD in relation to architecture is still missing. In our department, we have already taken the initiative to fill this gap.
5. Another research project having been neglected so far, concerns the present housing shortage. All agree that this problem is to be solved as soon as possible. However, using computers to support the modelling and construction of new housing projects, involves some problems. The danger of computer based standardization may occur, especially if the CAD application is linked with the automatical production of a small variety of construction parts by building industry. Thus, both aspects could coincide with some structural deficits in "mental" innovation and produce a difficult architectural problem in future.
6. Finally, architectural design research should focus on speculative considerations aiming to enlarge the range of architecture in order to express in an innovative way various meanings just as the notion of the perspective was visually expressed in Renaissance architecture. In our time, we could think of producing special forms, e.g. linked with the central CAD notion of "topology". So, the question "Is the computer more than a pure construction device?", still remains to be answered.

## 5. Further Objectives

Almost eighteen months ago, we started to build up the new teaching and research department "Computer-Aided Design and Construction in Urban/Environmental Planning". Up to now, the building-up has not been finished. The need for research is very high but it can be realized only partially and successively due to the shortage of staff. The teaching concept and contents, however, have proved to be successful, even if it has been evident that the technological developments, student knowledge at the beginning of studies as well as the level of technological equipment, need continuous efforts to match the requirements.

## Appendix

General view to contents of education

### 1. Computer-Aided Design and Construction in Architecture

#### a) Contents of Lecture

- Architecture and CAD - general view and fundamentals
- Technical presuppositions in using CAD
- Mathematical fundamentals for CAD and digital models in different space dimensions
- Data gathering for existing architectural objects
- Basic functions of computer graphic systems and specific functionalities in computer-aided design systems
- Methods of rendering and animation
- Computer-aided information processing in urban/environmental planning and the use of digital cartographic systems
- Computer-aided designing in development planning
- Synopsis and evaluation of existing CAAD-systems
- General view to programming methods and user programming languages
- Actual research fields
- Colloquy: extern experts inform about practical experiences

#### b) Exercises and Training

- Construction of an architecture object without any restrictions in shape and complexity; used CAAD-system: PROCAD (summer 1990)
- Variations to Le Corbusier's Weissenhof-building; used CAAD-System: PROCAD and SPIRIT (winter 1990/91)

#### c) Students' Resonance

80 students in summer 1990; 75 students in winter 1991 (total number of students in architecture around 700).

### H. Information Processing and Computer-Aided Design Systems for Urban and Environmental Planning

#### a) Contents of Lecture

- General view and fundamentals in techniques of information processing
- Types of software systems with relevance in urban and environmental planning
- Gathering of spatial data Geographic information systems and fundamental methods of computing digital raster and vector data

- Applications of using information processing systems in urban/environmental planning
- Computer-aided design in general land use planning and development planning
- Using computers for the planning of urban shapes and images
- CAD-systems for architectural designing
- Synopsis and evaluation of existing information processing systems in urban/environmental planning
- Fundamentals in programming techniques and the use of macro languages
- Actual research fields in urban and environmental planning
- Colloquy: extern experts inform about practical experiences

#### b) Exercises and Training

- Raster analysis to a given environmental problem (traffic noise); used geographic information system: ERDAS (summer 1990)
- Training at the geographic information systems ARC/INFO and ERDAS: data generation., handling of the overlay technique., representations (winter 1990/91)

#### c) Students' Resonance

35 students in summer 1990; 45 students in winter 1990/91 (total number of students in environmental/urban planning around 400)

### III. The Use of High-Level User Programming Languages in CAD-Systems

#### a) Contents of Lectures

- Introduction in using the CAD-system microCADDs/GCD and its linkage to the user programming language UPL
- GCD-commands and demonstration of basic constructions
- Designing, editing and compilation of programs
- Data elements, variables, declarations, basic operations, calling of library functions or GCDcommands
- Programming of sequences and control structures; basic input/output
- Developing of subroutines; file operations
- Program testing and interpretation of error messages
- UPL-library
- Introduction into the programming language C: syntax, using the editor, compilation, graphic tools
- General view to some other programming languages (ALGOL, BASIC, FORTRAN, PASCAL, PLI)

b) Exercises and Training

1. Developing a program in UPL to compute the overlap of polygons
2. Developing a program in UPL to compute perspective views of an architecture object as a wire-frame model
3. Developing of a Mandelbrot-fractal using the programming language C

c) Students' Resonance

30 students of architecture and environmental/urban planning in winter 1990/91.

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