FORM AND PERFORMANCE IN DESIGN EDUCATION (BAU 5)
(BAU - BASIC ARCHITECTURAL UNIT)

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Introduction

There are some fundamental issues in todays architectural education which seem important yet very hard to achieve.

One of this issues is the interdependence between design and technology. There is one group in architectural education which believes that the question of how to conceive (arch.) and how to construct (arch.) are interdependent. Consequently in this line of thinking the design concept requires verification on a technological level.

The second issue which has often been debated is performance. Related to it is a line of thinking which is not satisfied with the formal issues of design - and how it looks, but wants to carry design to point where you also know - what it does and with it how much it costs. Cost-consciousness is the final issue addressed.

Well. We all know that there are limits to what a school can do or what a school can be. And, there is an essential difference between practise and education. Yet at the same time the argument is that only consciousness is required thus leading to the basic understanding that form performance and costs are interrelated and interdependent issues in architectural design.

Project BAU 5

With all this in mind the project BAU 5 was conceived. This project is a cooperative operation between the design & technology group of Prof. Herbert Kramel in Zürich and the CALIBRE group, headed by Prof. H. Wagter in Eindhoven.

The generator of the project is work done previously at Eindhoven together with Liege and Strathclyde which became known as CALINCAD 1-2.

While Calincad was an incredibly sophisticated teaching and learning package in the area of thermal, daylight-, cost- and comfortcalculations, we found it somewhat lacking on the formal, or architectural level.

The project BAU 5 tried to overcome this problem through the combination of a first design module which deals with formal issues and a second design module which introduces the performance issues.

As a whole the project, still in a somewhat experimental stage, is intended to lead the student through various levels of choice and complexity in the hope and belief that through it the student could acquire a better understanding of the already mentioned interdependence between form performance and costs.

Every project has an institutional environment. Eindhoven and Zürich has been mentioned. At the same time each project has people directly responsible for the work. In Zürich this was Jürg Späti, at Eindhoven it was Rob van Zutphen who developed the Calincad package to the present, 2. module of BAU 5.

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The project environment

The environment for the project is all Macintosh oriented. In order to run both modules, a Mac II with min. 5 MB RAM is required. Standard programs and tools such as ArchiCad 4.0 and Excel 3.0 have been the base for the development of the present state of the project.

Module 1

As mentioned already, Module 1 dealt with the generation of the architectural object. In our case we conceived the overall object as consisting of three thermally insulated volumes (2 classrooms and a service unit) and an uninsulated connecting hallway.

The selection of this elements with predetermined dimensions allowed first a number of combinations (based upon criterias introduced by the student) which all have the same quantitative properties while architectural or qualitatively being very different. The combinations of the volumes together with the selection of the orientation created a quite large range of solutions which satisfied us as a point of departure. Since on this level only the volume is an issue a simple representation of the volumes suffices.

The next level of operation requires first a choice. One object has to be selected for further exploration and examination.

The second level tries to introduce space and structure as issues. Again elements from a library have been made available.

A first translation from level 1 to level 2 can take place automatically. Based on certain properties of the elements further manipulations can be made.
Various forms of representation allow an evaluation of the object through isometric, perspective, exterior and interior views.

The third level of operation introduces the notion of architectural expression through the introduction of the building envelope and with it material.

Again the student has the possibility to select elements from the library. With it he or she can increase the degree of definition. The model has again a higher level of resolution then previously and can be checked through various modes of representation. Additionally, lighting and shading can be introduced. With the choice of geographic location and time of the day this allows already some quite sophisticated results.
Summing up we want to point out that module I moves the student "vertically" through three levels of resolution and thus complexity. In addition to it the student is given on every level a range of choices based on predetermined libraries, thus having a "horizontal" option.

In this controlled process of design the student explores the evolution of complexity and the introduction of various issues in design.

At the end of this process an object exists, which the student understands fairly well in terms of form, space, structure and function. He does not yet know its performance Moving the object from module I to module II represents the next step in this project.

Finally it seems appropriate to say that seen from Zürich, the cooperation within project BAU 5 and the CALIBRE group in Eindhoven was most productive. After a long time of experimentation one has the feeling that meaningful exchange was taking place.

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Module II

Background

As mentioned the second module is concerning about performance calculations. The module is based on the program CalinCad, which stands for Computer Aided Learning in Computer Aided Design. It is a program which is the result from a COMETT project (1988-89). Participants of this project were ABACUS-Strathclyde University, Glasgow, UK; LEMA - Université the Liège, Belgium and CALIBRE - University of Technology Eindhoven, The Netherlands, together with three industrial partners. The goal of the project was twofold. Firstly to give students a clear understanding about the way computersystems can be used as a powerful and flexible technique for decision support in the architectural design process, concentrating on the performance and cost criteria. And secondly, even more important, to emphasise the paradigm of integration of different design disciplines within one concept based on the elementary, iterative model of analysis, synthesis, evaluation. The targetgroup were and still are first year students with little or no experience with computer aided architectural design and appraisal.

CalinCad is based on the computer program Ecole (1984) which in turn an improved version of DAFFY, Design Appraisal For First Years. DAFFY was developed in the early eighties at the Strathclyde University and is still part of their first year curriculum. CalinCad is used now for over four years within the curriculum of CALIBRE with great success.

Fig. 1. CalinCad

The strength of these programs is their interactivity and userfriendliness, the lack of complexity without losing sight of both goals and the reproduction of fast results with sufficient accuracy. This in contradiction with more professional building model systems. Generally these programs are used within research or industry because of their capability to handle complex buildings and perform accurate calculations. But because of their need for huge amounts of (rigid) data, the timeconsuming calculations and lack of interactivity, they are not suited for teaching junior students.

Another important advantage of programs like DAFFY and CalinCad has to do with the actual
development, the design and coding, of a program. When developing your own courseware it is important to know your capabilities and budgets. Interactive, userfriendly computersystems are very expensive to build. Therefore the aims shouldn’t be too high. It would be nice to have a realtime 3D design tool for complex buildings, performing all possible calculation in the background and having all data available instantly. But building such a system to use in curricula, if possible at all, would take hundreds of manyears and is not feasible to universities.

The second module: Performance module

In the first module students have to design a small building with several design objectives and constraints not only in the area of form and function, but also performance. Examples of performance criteria are maximum capital and maximum running costs, annual heating energy consumption and daylightfactors. Because the program is based on the ideal of integration, most of the constraints are in some way directly related to each other. For example, the size and type of a window not only influence the function and appearance of a wall but also criteria like costs, heating energy flow and daylightfactor. So, form, function and performance criteria are all strongly interrelated. This makes it difficult for the designer, in this case a student, to meet all requirements. Sometimes even adjusting the building design and materials is not enough. In that case it is necessary to change or just drop some of the requirements. Just as in real practice. The teacher can guide this learning process. He can increase or decrease the solutionspace by changing some of the objectives or constraints, making it easier or harder for the student to meet all conditions.

Important to notice is that on a highly interactive base the students observe and evaluate the effects of his/her design decisions without doing difficult performance calculations. That task is for the computersystem. And by doing so, the student is getting a better understanding and insight of cause and effect of it's design decisions.

Fig. 2. Performance Module
Development of the performance module

When teaching performance in architectural design to students of architecture the use of CAAD techniques is unavoidable. Performance calculations are too large and time-consuming and often too complicated to do by hand. Further it seems only rational to use computer techniques for evaluations if there are already being used for teaching form and function in design. At the ETH the computer program ArchiCad is used as design system in first years curriculum. Unfortunately, this package is not suitable for calculating performance criteria like energy consumption or costs. The program CalinCad used by CALIBRE was developed for a IBM-PC environment. For several reasons it was not attainable to rewrite it to run on an Macintosh computer. Known existing performance calculation programs are either too rigid in use and not open for adjustments, demands huge amounts of building model data before starting calculations, are unsuitable to integrate with ArchiCad and do not support real interactive use. Therefore the decision was made to develop our own performance package, based on the knowledge and calculation methods used in CalinCad.

Realizing that the development of courseware is a very complicated matter where different disciplines like CAAD, didactics, software engineering and others come together. And also realizing that cooperation between different universities in different countries also have their difficulties, the first goal to aim at was not stated too high and chosen on a responsible and realistic base. The premises used are the existing curriculum (educational goals) on both universities, the existing educational software and hardware, the available time and money to spend for this project and the available skills and knowledge of as well teachers as students. After some visits to each university, getting acquainted with each other goals, the lectures given, the materials and programs used and after several discussions, die choice was made to use the spreadsheet Excel from Microsoft as development tool for the performance module.

The main reasons for using Excel are the openness of the program and the suitability to make calculations. Excel is designed for that purpose. The availability on as well MS DOS as Macintosh computers is another advantage because, as mentioned before, CALIBRE and ETH are using these different computer platforms. Further, Excel it is easy to learn and program and has very good graphical possibilities which can be used to represent data more clearly to students.

Data exchange

The data exchange between the two modules is done using GDL file format. A design made by a student using ArchiCad is saved as a GDL file. This ASCII file contains information of the building elements in the design including position, orientation, surfaces areas and element type. Excel cannot read GDL files directly. This is done by special developed command macros on a macrosheet.

Calculations

For now the module calculates the annual heating energy and the capital and running costs. The calculation routines reside on macro sheets and the main user interface in build using a worksheet.

Both ArchiCad and Excel are using the same building-element database. This database, together with its own database of the performance module containing design independent information needed to perform the energy and cost calculations, the module evaluates the design, calculates the results and displays them on the computerscreen. The calculation methods are based upon standard calculation as described in existing NEN, DIN or ISO regulations. The student do not
need to known the exact algorithms used. Neither do they have to known about parameters like thermal conductivity of constructions although some understanding helps to make design decisions.

Fig. 3. Example of popup dialogbox. Used to change parameters.

Excel supports some powerful userinterface elements. (See Fig. 3) For example buttons which are used in the module on the worksheet to activate calculations or call dialogboxes. Another item Excel supports to change parameters or elementtypes.

The student can change different parameters of the design like the type of wall-element, the area of glass, the constructiontype, the orientation of the design, the insulation thickness in order to meet the performance requirements. Because all criteria are somehow related as explained earlier, the student has to think carefully before making a decision.

This idea of simulation using a computersystem stimulates students enormously as we have learned from the program CALINCAD. Every year again, without asking them, students make a competition of who makes the "best" design as far as meeting the requirements. And this is also very stimulating for the teachers.

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