ARCHITECTURAL PROGRAMMING WITH CAD

Alin Décoppet, professeur
Ecole Polytechnique Fédérale
Lausanne
Département d'architecture
12, Av. de l'Eglise-Anglaise
1001 Lausanne - Switzerland

Dr. B.]. David
laboratoire IMAG
University of Grenoble
BP 53 X
38041 Grenoble Cedex - France

ABSTRACT : We would like to explain to you the programme for a ten-week workshop spending ten hours per week on the architectural programming of a particular project.
We have developed a special methodology which is a synthesis between Architectural Programming Methodology and Integrated CAD Methodology and have used it on two occasions.
We would like to describe our experience with this workshop.

1. WHAT SHOULD BE UNDERSTOOD BY ARCHITECTURAL PROGRAMMING ?

A definition of the object to be constructed is obtained from a number of data representing the requirements and the wishes of the project leader. They are :

- the basic reasons for creating the object and the purposes assigned to it by the principal
- the guiding principles of the project which will influence it a great deal (e.g. economic restrictions)
- the functional requirements
- the constraints and imperatives to be respected.

These data form the programme of intent, the initial rough specifications of the object to be built. Architectural programming is the action which makes possible the transition from the initial rough specifications to the final detailed specifications of the operational architectural programme, the basis of the design. This is a question of assembling and synthesising. There are two approaches which can be used to obtain the result:

- implicit : proceeding without apparent method, without external justification, relying on experience and intuition. This is the approach most often followed by architects; it leaves them complete freedom of action, judgment and responsibility. Subjectivity is the essential ingredient of this method which makes justification and collaboration difficult to obtain;
- explicit : proceeding in a more orderly fashion referring closely to the detailed clarification of the design process as it takes place, i.e. to predefined behaviour Patterns based on which the work is to be carried out. In this way the work is more systematic which helps in allocating tasks and in achieving collaboration between the various people involved and in the application of procedures which can aid the architect in his project study. One of the procedures the architect can use is computer-aided design (CAD), i.e. using the computer as an aid to planning an architectural project.

2. METHODOLOGICAL CONTEXT

An explicit approach requires the basic definition of three components:

- the design process to be used for the project, specifying in particular the various stages of development
- the purpose of the action, i.e. what does it concern, specifying what must be taken into account in the development of the architectural object and the results
- the manual, automatic or interactive processes, which are desirable.

In fact the approach should be modelized in a rather complete and complex way taking into account modelling criteria such as:

- the fineness level of the modelling
- the generality level of the model being developed
- the possibility, to be left to the users, of extending the model.

The generality level leads on to the idea of concrete and abstract models. If we modelize a specific project directly, school buildings for example, we obtain a concrete model. In the same way, by modelling a living accommodation project we obtain another concrete model. If we look for the common factors in various models and this investigation reveals sufficient representative elements which give the models certain similarities, this may lead to the development of an abstract model (bringing us near to the idea of type). While doing this we deliberately put aside what is specific to the project, i.e. the precise semantic meaning, in favour of a structural result; this is a process of generalisation and abstraction. When the abstract model is established it is possible to produce a tailormade concrete model for a given object. An abstract model in fact generates concrete models (Fig. 1). The transition from concrete to abstract reveals the essential structure of the problems in relation to the specificity of each project. A concrete model built from an abstract one benefits from all the advantages, that is to say from the generality of the abstract model and from its own specificity. Modelling of abstract objects in a project causes structuring elements to appear which are called design units. Each design unit is given a particular form by qualitative , quantitative or temporal properties. Furthermore, it is necessary to emphasize the links, i.e. relationships, between the various design units, which are made specific by a property defining the nature of the relationship. The abstract model process defines all the processes the designer can use during designing. There are basically three types of process:

- analysis make studies to understand better, define
- synthesis relate various pieces of knowledge, extract new information

- checking : make a study to see if the behaviour is satisfactory.

3. ARCHITECTURAL PROGRAMMING WORKSHOP

3.1 Teaching Plan

Learn to constitute a general framework of documentation, to re search and assemble the date and specific conditions, to define objectives, determine the area of activity, find the directing principles. fix and apply evaluation criteria, decide, choose, write.

3.2 Action taken by

- students in different roles (project leader, architect)
- consultants, documentalists, project leader
- teachers and assistants during the study.

3.3 Method of Work

- Plenary sessions (presentation of basic logics, informal lectures, choice)
- Small groups (development and written work)
- Individual (reading - with note-taking - architectural sketches,
- presentations).

3.4 Procedure to be followed for the study

- Documentation (including development of the system of intent of the principle)
- Definition of the object (organizing of data and constraints)
- Defining of the range of action (by date processing)
- Search for solutions
- Final programme proposal.

4. CAD APPLIED TO PROGRAMMING

To set up a CAD system for programming it was necessary to combine two elements, firstly the "manual" programming used by teachers in the workshop (Fig. 2) and secondly the CAD procedure developed by a research group from IMAG Grenoble. This combination resulted in a five-stage procedure as follows (Fig. 3):

1) Preparation of the concrete model:
Data selection, calibration of the model, determining of design units (activities), properties and significant relationships, behaviour study.
2) Statement of the "project" by evaluation of the properties and relationships fixed in stage 1.
3) First valued synthesis of the concrete model : choice of basic architectural principles by analysis of properties and relation ships, passage of activities to spaces.
4) First space proposals : partial sketches (qualitative, functio nal).
5) Development of the final sketch; writing of the architectural programme.

4.1 How is the concrete model established?

It must be specified here that IMAG put at the disposal of the programming workshop a logical framework corresponding to an abstract model previously developed by them. The concrete model is therefore not established around an object to be designed, but from an existing abstract model provided with data relating to the object to be designed. These data, stated previously, define what the object is and what happens in it, they are

- a complete list of the design units, i.e. in the present case the main and secondary activities which take place in the object to be designed
- a complete list of the significant properties noted for all the activities
- a complete list of the significant relationships noted from all the activities and a list of the significant relationships between activities.

A design unit, here an activity, will therefore be determined by the properties on which it calls and generates, which themselves are then characterised in quantity and in time, and by the relationships they have with the other activities.

The choice of the different data from which the concrete model is produced is not easy and it is necessary to refine the choices progressively, i.e. to calibrate the model to retain only the significant data in relation to the objectives of the project. This calibration is done by studying successively the behaviour of the activities, the properties and relationships with the help of specific computer programmes:

- a programme for studying the behaviour of the properties an activities (PROPACT); concerning activities this programme gives: the degree of qualification, the distribution, the degree of resemblance of the activities in relation to the properties; concerning properties the programme gives: the frequency at which the properties appear in the activities, properties concerning the same activities, the distribution of the properties in relation to the activities, the degree of resemblance between the properties;
- a programme for studying the relationships between the activities (ACTACT) judging the activities in relation to the relationships, i.e. to determine their degree of overlapping and proximity, and judging the relationships in comparison with the activities by bringing out the relative importance of the relationships.

These programmes will be used also for stages 2), 3) and 4) men tioned above with data adapted to the progression of the study.

4.2 <u>What is included in the project statement</u>?

At this level of progress (first stage), the abstract model has been given all the significant data; <u>it has become a concrete model for a family of projects</u>. It must be specified that no piece of information is quantified, but simply characterised by its presence or its absence and by the presence or absence of relationships with other data. The purpose of the second stage is to determine the effective values of these data, to evaluate and quantify the project using a predetermined progressive scale of values. These values are applied to matter identical to that used in stage 1) and will serve as a basis for the simulations done in stage 3).

4.3 Study of the object to be designed, attempted synthesis according to the basic architectural principles chosen

It is possible at this stage to do attempted synthesis based on a chosen basic architectural principles. What should be understood by chosen basic architectural principles? It means that a relative importance should be given to the properties and activities present in the project. The degree of importance given to any one property (e.g. protection against fire) will have a proportionally strong effect on the project. As for the relationships between activities, should priority be given to the movement of people or of materials? The layout of the premises will change depending on the choice made. The degrees of importance chosen will be taken into account in the tables obtained in stage 2) (PROPACT for the properties, ACTACT for the activities) and make it possible to obtain new tables to be processed by the computer. At this stage the idea of space must be introduced and this will subsequently lead to the spatial allocation. In fact, up to now reasoning has been done on activities only, now we must regroup the activities with appreciably the same performances both from the point of view of properties required and the relationships bringing them together. The new ideas will be introduced in the PROPACT programme which then becomes PROPESP. After this stage the existing concrete model becomes a new concrete model into which are introduced the functional spaces characterised by the valued properties special to them and by the relationships which link them.

4.4 First space proposals

The new concrete model obtained during the previous stage makes it possible to consider the question of space allocation. This is done using two simulations. With the first a qualitative sketch is obtained as it is based on the properties (qualities)found in the functional spaces; the result will be a sketch which regroups the spaces in the best way by "qualitative affinity" and gives priority to this idea. With the second simulation a functional sketch is obtained as it is based on the relationships of proximity, the connection between the activities found in the functional spaces; the result will be a sketch which regroups the spaces in the best way, taking into account the intensity of the relationships between the spaces.

Using the space allocation programme (ALLOC) these sketches can be obtained based on :

- a list of the functional" spaces established in stage 3)
- the surface or geometric shape quantitative properties
- the links between functional spaces.

4.5 Development of the final sketch and the architectural programme

The purpose of this stage is to study the final space proposals, i.e. to find a compromise between the qualitative and functional aspects established previously.

The result is a final sketch produced from

- the functional spaces retained and their surfaces
- a new relationship, compromising between the qualitative and functional relationships and based on a chosen course of action establishing the relative value of the main data.

This sketch is obtained with the help of the space allocation programme (ALLOC) which will express a space sharing corresponding to the courses of action chosen. Each change in course of action will lead to a different final sketch so that different possible solutions can be presented. The architect will make a choice on the basis of these proposals.

The programme for the object to be built can now be written not only on the basis of the formulated intentions, but also of the data processed, which produce a solution in the form of a sketch fulfilling the initial requirements.

5. EXAMPLE OF A THEME FOR AN EXERCISE

Study of a wine-producing establishment engaged in all the stages of production of red and white wine from the grape harvest to delivery of the finished product.

5.1 Vinification Operations (information obtained from Mr. Mathys, engineer and oenologist for the Canton of Vaud)
Weighing of the grapes, pressing, testing, second pressing, sulphate treatment, decanting, settling, sweetening, fermentation with yeast, removal of stalks, settling, alcoholic fermentation, removal of sediment, casking, acid removal, retrogradation, stabilisation, decanting, thinning out, filtering, bottling, storage.

5.2 Associated Activities
Water purification, storing of materials, shop, workshop, cellar for winetasting and refreshments, production of heat and cooling, etc.

5.3 Properties
Temperature, relative humidity, ventilation, lighting, water supply, compressed air, noise, type of earth ..., surface area requirements, height requirements, personnel..., outputs, distances, container capacities, time required for each operation ...

6. WHAT CONCLUSIONS CAN BE DRAWN?

6.1 In relation to teaching :

- a good teaching tool as it can explain clearly an approach which is often exclusively subjective, irrational and not communicated
- a good introduction to data processing for an architect-project leader (on the condition it is supplemented by an initiation course) who immediately understands the idea of aid, assistance, in relation to the false idea of "automatic design".

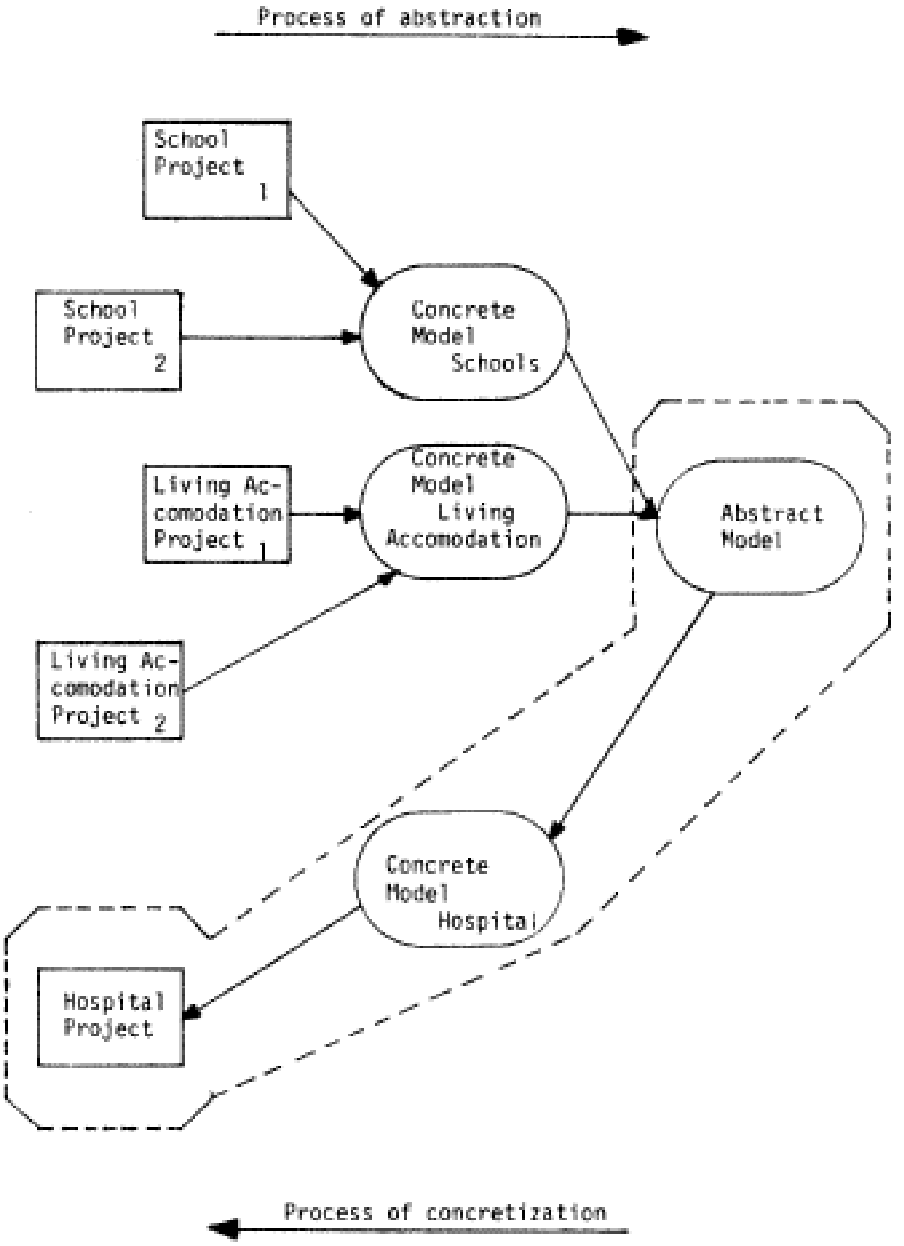
6.2 In relation to practical work

- presents the man-machine relationship well (communication); forces understanding (still difficult) between users and data analysts (pooling of knowledge)
- shows the present limits of data processing in architecture (a field which is not only technical) : an aid, not a substitute
- a useful process, probably not profitable below a certain degree of data complexity.

6.3 <u>In relation to the test itself</u>

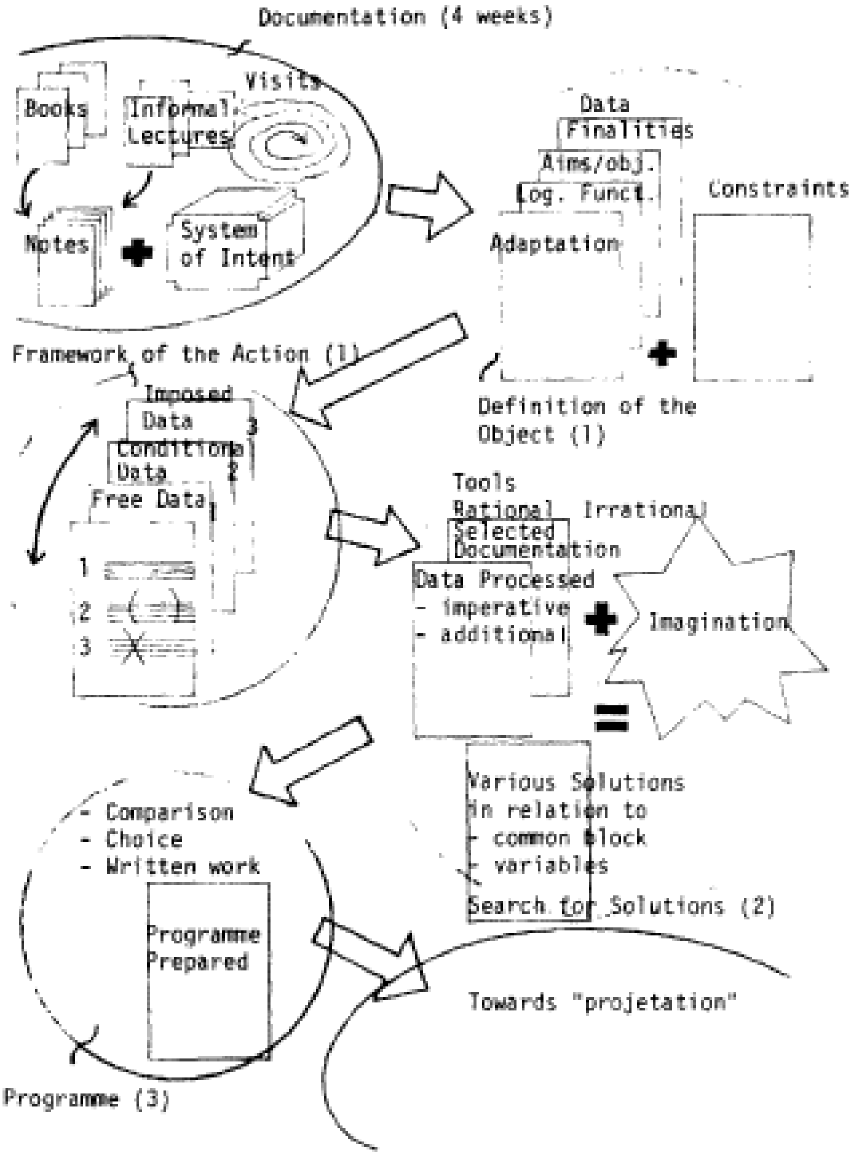
- interactive regime almost essential
- excellent internal collaboration at EPFL (mainly between the Architecture Department and the Calculating Centre) and interuniversity (EPFL-IMAG).

Fig. 1



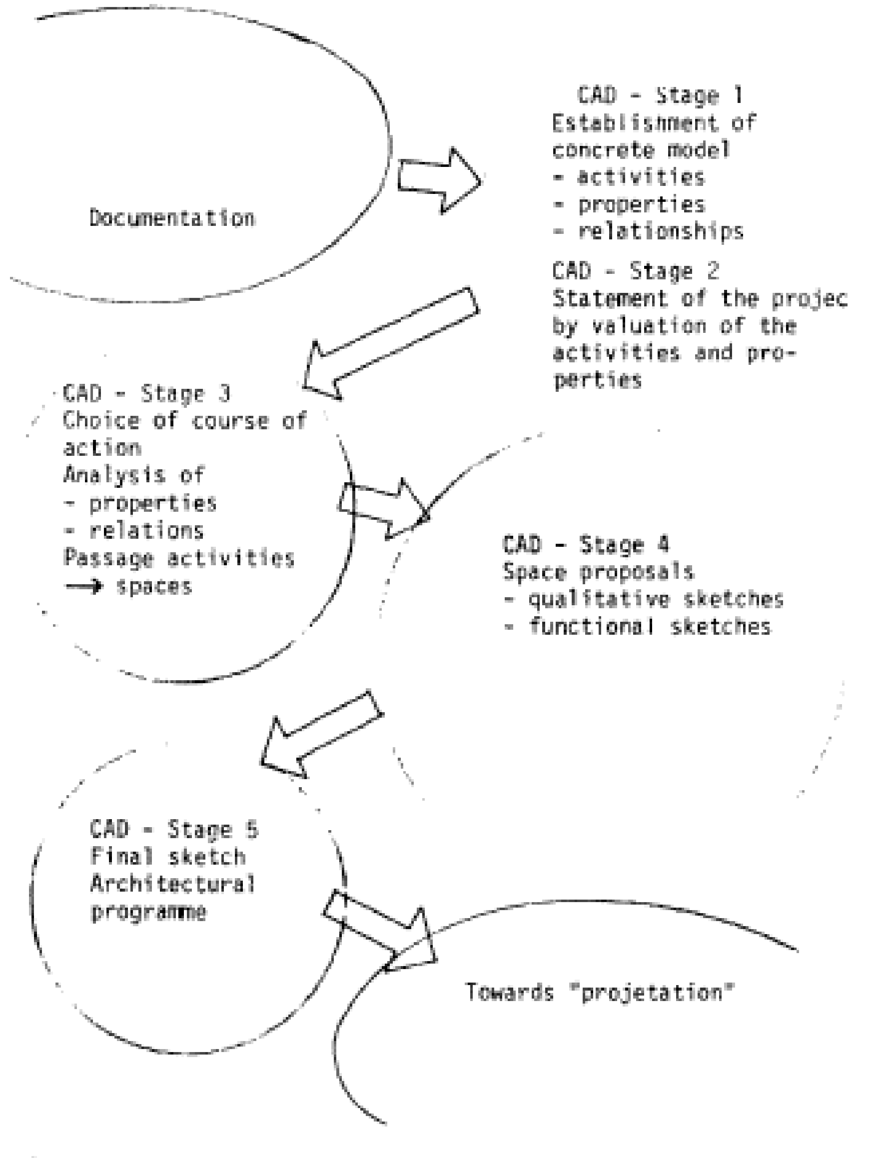
Process of abstraction
School Project 1
School Project 2
Concrete Model Schools
Living Ac-comodation Project 1
Concrete Model Living Accomodation
Abstract Model
Living Ac-comodation Project 2
Concrete Model Hospital
Hospital Project
Process of concretization

Fig. 2



Stages of the Preparatory Study

Fig. 3



Architectural Programming with CAD