METHODS AND MODELS: ALIVE AND WELL AT STRATHCLYDE

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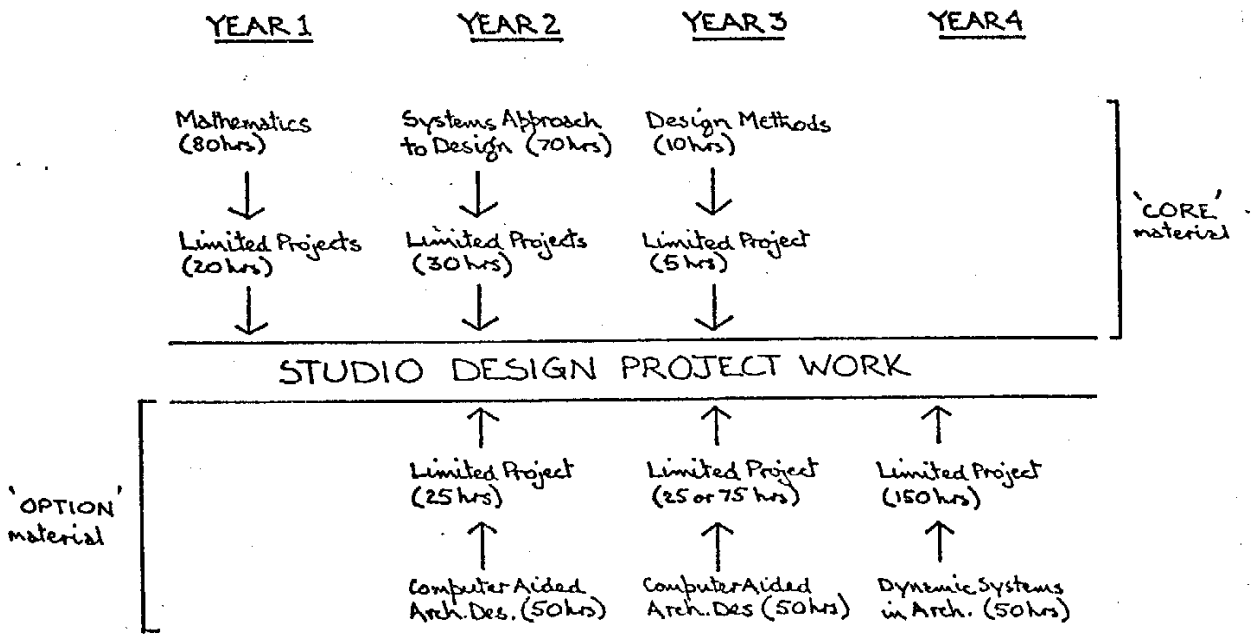
1. INTRODUCTION

Students currently in Schools of Architecture will be at the peak of their careers around the year 2000. The pressure on the Schools to provide an education and training which will stand the student in good stead between now and then is considerable. In the Department of Architecture and Building Science at the University of Strathclyde, importance is placed, within the course, on the concept of modelling: i.e. the development and use of models of the operational behaviour and aesthetic character of design proposals which will allow prediction of how real building will perform in the real world. The belief - supported by a growing quantity and quality of evidence - is that access to and use of explicit models of the future built reality promotes:

a) retention of studio project work as the core synthesis discipline within the educational environment.
b) an appropriate degree of independence from the prevailing corpus of factual - but highly perishable - information on materials, constructional detail, etc., and
c) a focussing of attention on the value judgements (and hence the morality) which always have - and properly always will - pervade architectural design decision-making.

2. COURSE STRUCTURE

Strathclyde operates a 4 year/1 year pattern of studies. The first 4 year period of continuous study results in an honours BSc degree; within the first three years of the BSc course the vast bulk of the core material required to satisfy Part 1 of the RIBA requirements is covered, leaving in the fourth year, the opportunity to take a selection of topics to an advanced level. A year out, in practice or in research, completes the requirement for entry to the 1 year BArch course.



The education activities which relate to design methodology are structured as shown in Fig. 1. It will be seen that the intention is to effect an integration of formally taught material whether 'core' or 'optional' into Design Project Work via sets of carefully constructed Limited Projects.

3. COURSE CONTENT

3.1 'Core' Content

All students entering the Department are required to have an 'A-level' (GCE) or an 'H-level' (SCE) qualification in Mathematics. The first year mathematics course of 100 hours, which builds on the entry qualification, is taught by mathematicians to a unique syllabus specified some 3 years ago by the Department of Architecture. This syllabus which replaced the standard maths course offered to technology students throughout the University, is intended to expose the 'structure' of the mathematical theory which forms the basis of the topics relevant to architectural design. The topics include Boolean Algebra (sets, dendograms, etc.); Probability Theory; Finite Markov Chains; Matrix Algebra; Linear Equations; Affine Mapping; Perspective Geometry; Graphs and Networks; and, of course, Calculus. Occasional lectures and half-day projects are contributed by members of the staff of the Architectural Department (3 have dual architectural/mathematical qualifications) to illustrate the applicability of the theory.

The issue of applicability of the mathematical theory to modelling in design decision-making is rigorously developed in a 100-hour 2nd year course 'Systems Approach to Design Decision-Making'. Organized around a set of 10 Limited Projects, each occupying a half-day, the instruction material covers System Concepts; Graph & Network Theory applied to layout generation; Probability Density Functions applied to facility provision; Economics applied to cost-benefit and cost-effectiveness; Combinatorial Programming applied to location/allocation and distribution networks; Markov Chains applied to accommodation provision; Simulation applied to movement studies; and Significance Testing applied to model validation.

The 10 half-day projects in the Systems Approach course are all limited objective design exercises, mostly computer-based: for example students are required, in one such Limited Project, to arrive at a balanced and economic level of provision of facilities in a Ferry Terminal by iteratively simulating the flow of passengers and vehicles through the terminal complex.

In third year a shorter (10 hours) course on Design Methodology orientates the student away from the mathematically based methods which tend to be drawn from other disciplines, towards the increasing repertoire of 'home-grown' methods and models which are altogether more heuristic, pragmatic and multi-variate. The course is structured in terms of the Objective System (- the planning phase), Variety Development (- the synthesis phase) and Variety Reduction (- the appraisal phase). Case examples are used to assess the applicability of each method.

The pass rate in these three core subjects is high - 80% and over. This figure compares favourably with other subjects in the curriculum and compares very favourably with the 50-60% pass rate which prevailed when the standard, but no more rigorous, 1st year maths course for Technology students formed part of the curriculum.

3.2 Option Content

In 2nd and 3rd year the core material is supplemented by 75 hours of option time. The option most closely related to design methodology is Computer Aided Architectural Design.

The CAAD option, taken first time round, is divided into three sections:

a) A set of lectures describing the nature of the design decision-making activity, including details of some of the processes and techniques involved. Where it is possible the processes or techniques are described with reference to the computer and indeed in most cases programs exist which are described and/or demonstrated to the students.

   Since a major part of both design decision-making and computer-aided architectural design is concerned with the objective appraisal of design alternatives a fair proportion of these lecture/demonstrations are devoted to it.

b) A set of lectures, prepared from past experience, in teaching programming, has been produced using a simple sub-set of FORTRAN IV. This subset which has been produced for three computers (GE415, NOVA 820, UNIVAC 1108), contains sufficient information to allow a student to begin writing elementary programs without any other reference. Included is a set of exercises with possible answers.

c) A Limited Project in which the student is required to identify a methodology appropriate to some sub-problem of architectural design, set down the logical sequence for implementation of the methodology, and write, compile and debug a program which other students may easily use.

Students opting for the CAAD option in the subsequent year devote the full 75 hours to a more ambitious Limited Project around which instructional and tutorial sessions are arranged. Outcomes from the project work make a significant contribution to the repertoire of programs available to the student body. These include:

a) program for determining the minimum cost strategy for stepping and staggering terrace housing on a contoured site.

b) program for automatic scaling of computer-generated perspectives to fit photo-montage prints.

The 4th year of the BSc course consists largely of options with students selecting three honours level subjects from the ten on offer. Methodology and modelling is the theme of one of the subjects offered - Dynamic Systems in Architecture. Dynamic models relevant to the flow of materials, the flow of energy and the flow of information are discussed and tested in this subject and, if they so elect, students may proceed to a 5-week project within which they themselves construct a dynamic model of some building sub-system. A recent example of the outcome of a 5-week project was a computer-based method of movement simulation applicable to evacuation of a building following the outbreak of fire.

4. DESIGN APPLICATION

The acid test of the 'core' and 'option' inputs to the course is the degree to which students are motivated to draw on them in the Design Studio. Increasingly in the 4 year BSc course and the 1 year BArch course students at Strathclyde take advantage of the variety of design methods known to them. Advantageously, the majority of these methods are embodied in computer software which is readily accessible to the student body via a number of interactive graphical terminals sited within the Department.

It is increasingly common for students at all stages in the course to use the computer facilities as they might use their drawing board or the Information Room; the difference is that the facility is not simply a device, like the drawing board, or a knowledge base, like the Information Room. It represents, rather, access to design methods which allow exploration of, and insight into, the causal relationships between the design variables over which the student has control and the performance variables which will characterise the product.

Worth detailing, perhaps, is the recent experience of making Design Method the central theme in one of the BSc final year studio design projects. The project extends over five weeks and must culminate in a set of design drawings for a small hotel. The stages in the project are as follows:

1. Analysis:

Conventionally, in a project of this scope and scale, the brief issued to students would include a definitive schedule of accommodation. In this case, however, students were not provided with an accommodation schedule but with basic data on the unit areas of the various functional spaces within the hotel - single bedrooms, double bedrooms, function suite, restaurant, grill and lounge bar - together with the tariff structure, unit profitability and a probabalistic statement on occupancy at different seasons of the year. Additional data covered square metre costs for construction, rates and maintenance, administration and heat, light and power.

Using a specially devised program known as INVEST - based on a linear programming algorithm - students were able to establish that schedule of accommodation which maximised profit, subject to a set of administrative and planning constraints expressed in the brief. The program output included not just the optimum schedule but the corresponding generalized figures for capital and running costs. These costings thus formed 'targets' to be met in the design.

As the occupancy data provided was probabalistic and seasonally dependent, each studnet, by the end of the first week of the project had to submit to the client (i.e. to the tutors) a proposed schedule argued on the basis of the analysis procedure. Over the weekend the tutors considered the submissions and agreed a common brief for all students.

2. Synthesis:

Armed with an accommodation schedule and 'target' costs the students were given a week to generate, by conventional means, one or more 'outline proposals' as to the form of the hotel.

3. Appraisal:

The computer program SP3HOTEL is an integrated appraisal model intended for use at the Outline Proposals/Scheme Design stages. Students were able to input their design hypotheses by digitizing their layout drawings and by choosing from a file of constructional elements. The output from the program provided a check of

accommodation areas, predictions of environmental conditions and a prediction of how any particular scheme compared, in capital and running costs, with the 'target' figures of the brief.

Typically, students would interactively explore alternative geometries using a standard construction then begin to 'fine-tune' the scheme in terms of constructional decisions.

It was also possible to automatically produce perspective views of any scheme, using the program BIBLE, at a scale appropriate for immediate photo-montage on photographic prints of the site.

Submissions had to include the conventional plans and elevations and a clear account of the process of search and trade-offs which had led to the final scheme. Conclusions drawn by the tutors from the presentation and debrief sessions were as follows:

a) deploying a methodology to generate a functionally appropriate brief (in this case one based on maximum profitability subject to planning and administrative constraints), rather than accepting one 'ready made', greatly increased the students' motivation to meet the brief requirements.

b) ready access to an interative appraisal methodology motivated almost all students to explore a wider range of alternatives than would otherwise have been the case.

c) different students benefited from the rigour of the methodology in different ways: those considered 'weak' in design started with a mundane scheme which was close to the requirements of the brief and then used the appraisal program to become progressively more innovative within the envelope of feasibility; those considered 'articulate' in design started with an innovative scheme which broke the requirements of the brief and then 'tightened up' to meet the brief while preserving the innovative concepts.

d) the outcome, in all but one case, was a 'better' design than would have been expected from a conventional project. The single exception was a student openly hostile to any form of design methodology.

5. TEACHING PACKAGE

The CAAD aspects of the Strathclyde course have now been put into a teaching package which can be acquired by other schools. The main feature of the package, which includes lecture and project material, is a piece of software known as PIGLET (Package for Interactive Graphics Layout Evaluation in Teaching). The user graphically inputs the plan form of a building; PIGLET 'interprets' the form by taking off all the fundamental geometrical measures which are then stored in a strictly pre-arranged order in a file (Figures 2 and 3). The data in this file can be accessed by a 'CALL' from any applications routine devised by the user. Consequently, students can be encouraged to devise a method for predicting, say, daylight levels and to write into their sub-routine the appropriate calls to the geometry file. Thereafter any plan-

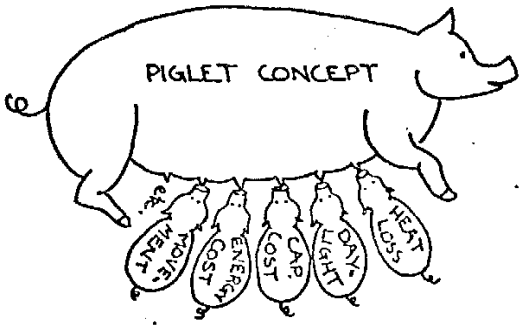


FIGURE 2

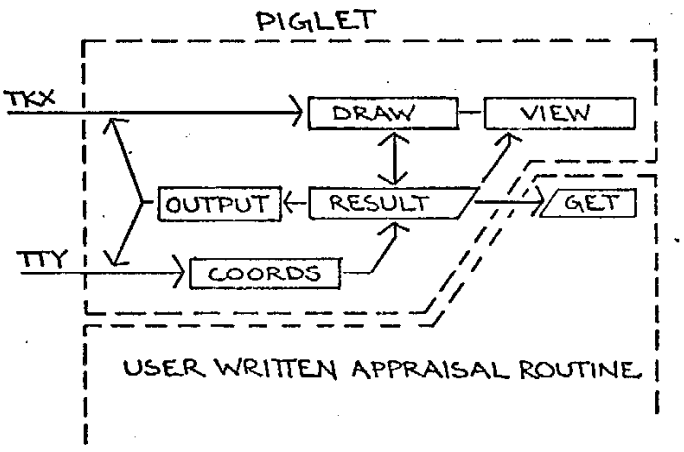


FIGURE 3

/orm and any exploratory variations of it proposed by the user can be appraised in terms of daylight levels. In this way, using PIGLET as the armature, an increasingly comprehensive and integrated appraisal package can be constructed.

6. CONCLUDING REMARKS

In response to Bob Fowles question, 'Whatever happened to Design Methods in architectural education', the Strathclyde answer would be: 'They are alive, well and living in the cores of an increasing number of computers. It is my view that the future credibility and survival of the architectural profession will depend in large measure on familiarity with, access to and development of computer based design methods. It is vital therefore to introduce the concepts and practice in Schools of Architecture; this has been possible at Strathclyde only through the committment, ability and vision of a large number of research workers and teaching staff whose contribution I gratefully acknowledge.

7. REFERENCES

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