CAAD IN ONDERWIJS EN ORDERZOEK

Professor T W Maver, TH Eindhoven

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 an increasing number of departments of architecture and building science, importance is being placed on the concept of modelling: ie the development and use of models of the operational behaviour and aesthetic character of design proposals which will allow appraisal of how real buildings will perform in the real world.

Appraisal is that process within the design activity concerned with the testing of design hypotheses. In computer-aided appraisal, the testing is done on a computer-based model of the hypothesised design; in effect the model allows a prediction to be made of the quantitative and qualitative attributes which will characterize the real building. The process of computer-aided appraisal is as represented in Figure 1.

The student designer generates a design hypothesis; this hypothesis - essentially the proposed form and fabric of the building - is input to the computer program. The program models the behaviour and characteristics of the building, as if it existed in reality, and outputs predictions as to the cost (capital and recurring), performance (spatial, functional, environmental) and visual quality of the design. The student in his/her evaluation of the output profile, modifies the design hypothesis. The iterative process continues until the student is satisfied that the balance within the profile, and between the profile and the more qualitative output, is optimum.

Clearly, if the process is to promote design decision-making which leads to improved quality in the built environment, the information profile provided by the output must guide the student towards those design modifications which bring about significant improvements in some aspects of cost and/or performance without significant deterioration in the others. Initially, degree of improvement or deterioration might have to be judged against arbitrarily set upper or lower limits of cost and performance. As an increasing number of design alternatives are explored, however, insights are provided into the complex relationships which translate unit change in one variable into corresponding changes in all other variables (Figure 2).

GOAL and BIBLE (Figure 3) are examples of computer-based appraisal models which can be used equally by designers (as we have seen from Leen Kraal's presentation) and by students at the early stages of building design. The intention is that it should be easy for the designer to input his/her design hypothesis, that the range of cost and performance predictions should be comprehensive and understandable, that it should be readily accessible and inexpensive to use and that it should be as applicable to the redesign of existing buildings as it is to the design of new buildings.

The designer can represent the geometry of his design hypothesis to GOAL in a variety of ways: by typing in the co-ordinates, by digitizing a sketch on a tablet or by drawing on the screen of a computer graphics terminal. The geometry, input floor by floor, is shown on the screen and can be manipulated using a cross-wire cursor in conjection with a command menu (Figure 4). The program allows a number of views to be obtained: floor plans, axonometrics, sections and, in conjunction with the program BIBLE, perspectives views. As soon as the scheme is input to the computer, a summary of areas can be obtained (Figure 5).

The designer now specifies the desired construction by choosing from a variety of constructional components. The program stores the unit cost and thermal properties of the constructional components within a number of constructional types. As wall and roof components are selected the designer also specifies the percentage glazing required. With construction specified and summarized, the program can output environmental information regarding rates of winter heat loss or summer heat gain, together with an analysis of energy loss and gain due to insolation, conduction, ventilation, occupancy and lighting.

Capital and running costs are output in summary and detailed forms.

Following each section of output, the program offers the designer the opportunity to change his design hypothesis. By this means a very large number of design alternatives and design developments can be explicitly explored in a very short period of time.

The program GOAL has been used in a wide range of educational contexts. The case study which is summarized below typifies the iterative search which a student is capable of making with such a powerful tool: first an exploration of geometrical forms followed by an exploration of constructional alternatives.

Figure 6 presents a summary of the four formal layouts explored by the designer. For each layout, GOAL provided, amongst other things, data on the wall-to-floor ratio, volume compactness, annual energy consumption, artificial and natural lighting, satisfaction of the energy regulations, running and capital costs and the all important matter of profitability. These cost and performance characteristics have been compared by the desginer in Figure 6.

At this stage in the development of the desgin, the designer made the subjective value judgement, based on the profiles of Figure 6 that geometry 4 offered the greatest potential. The second phase of the appraisal involved comparative evaluation of constructional systems as applied to scheme 4; firstly, three wall types were tested, then two levels of glazing, both single and double glazed.

Clearly then, the explicit information provided by the GOAL program promotes an informed value judgement. This judgement will have been influenced, and rightly so, as much by the perspective sketches (Figure 7) based on the output of the BIBLE program as by the designers rigorous approach to the appraisal of design alternatives and their impact on profitability.

The program GOAL is now in use in a number of European Schools of Architecture Resulting from each studio project, then, a wealth of data is generated concerning the cost and performance characteristics of a range of design solutions. The analysis of this data is a most approriate research subject in schools of Architecture and the computer program GLOSS is a suitable analytical tool.

After each run of GOAL, the output - 23 measures which summarise the design and its cost and performance characteristics (Figure 8) - may be passed over to GLOSS (Figure 3). It is thus possible to accumulate the design, cost and performance characteristics of a set of design solutions as a data-base on which a variety of analyses may be performed.

The output from the analyses which GLOSS can perform may take a number of forms, including the following:

Tabular : output, in the form of a table, of any set of cost and performance variables relevant to any set of design solutions

2-D graph : a simple graph with any design variable on the x-axis (eg wall glazing) and any resulting cost or performance variable (eg annual energy consumption) on the x-axis

3-D graph : a three axis graph with any two design variables (eg geometry types, construction types) on the x and y axes and any resulting cost or performance variable (eg capital cost) on the z-axis (Figure 9).

Profile : a histogram of the cost and performance attributes of any design solution; the base line of the histogram can be specified by the user as, for instance, the average values across the set of design solutions (Figure 10).

Clearly, then, the more often GOAL is used to appraise alternative designs, the bigger will grow data base of design solutions and the more reliable will become the analyses carried out by GLOSS. In this way students and research workers can, together, begin to understand the relation between design decisions and the resulting cost and performance characteristics.

The new generation of design aids offers us the prospect, for the first time, of understanding and controlling the complex activity of design.

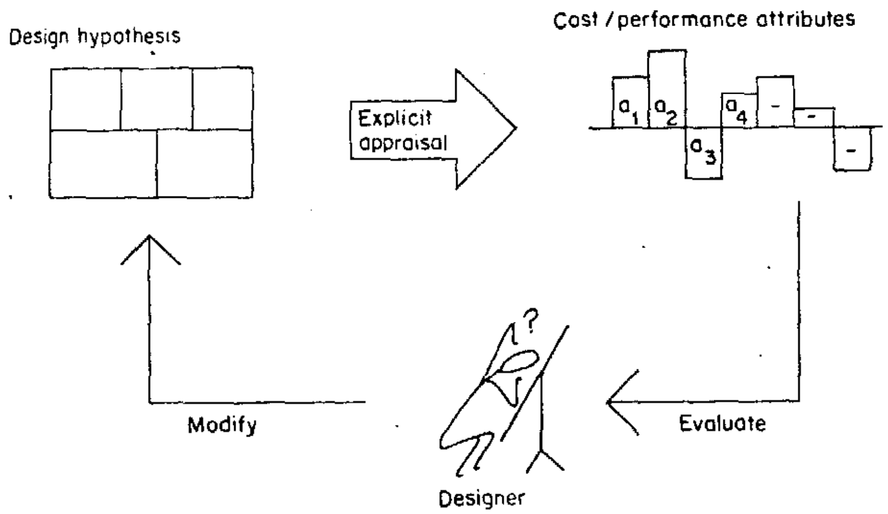

Figure 1 The concept of computer-aided appraisal of building designs

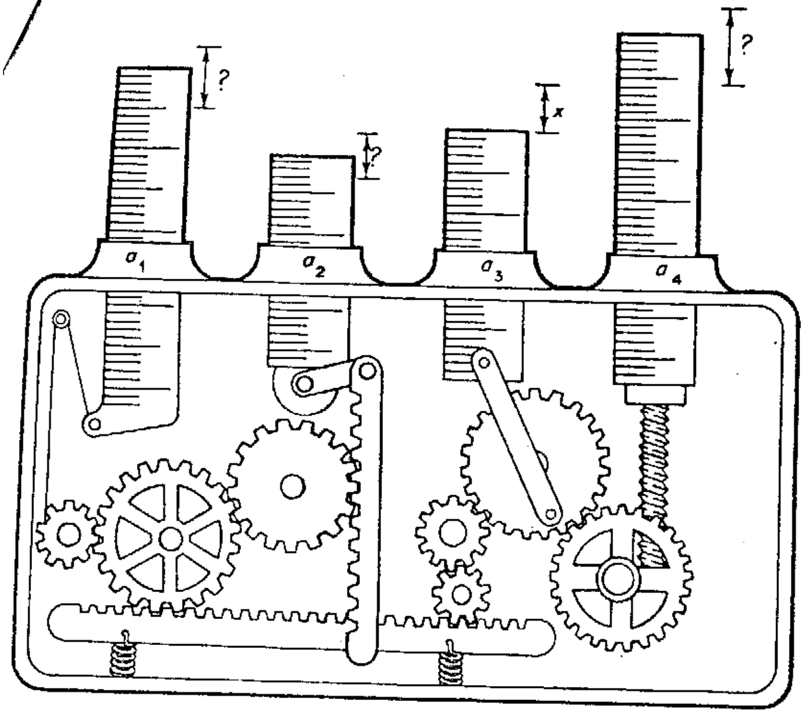

Figure 2 A representation of the complex interaction between cost and performance variables

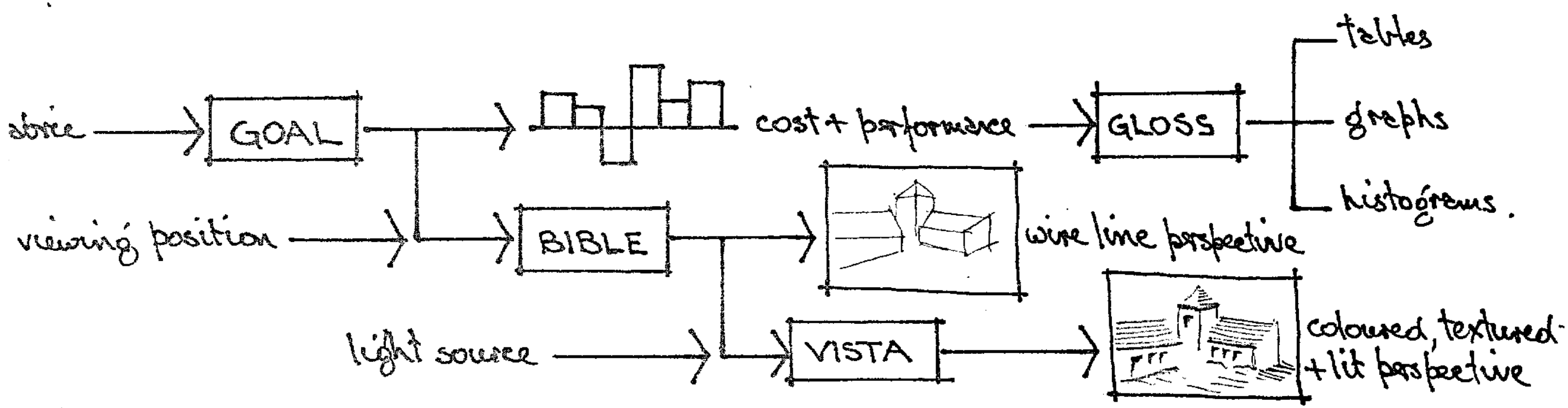

FIGURE 3. The relationship between computer programs.

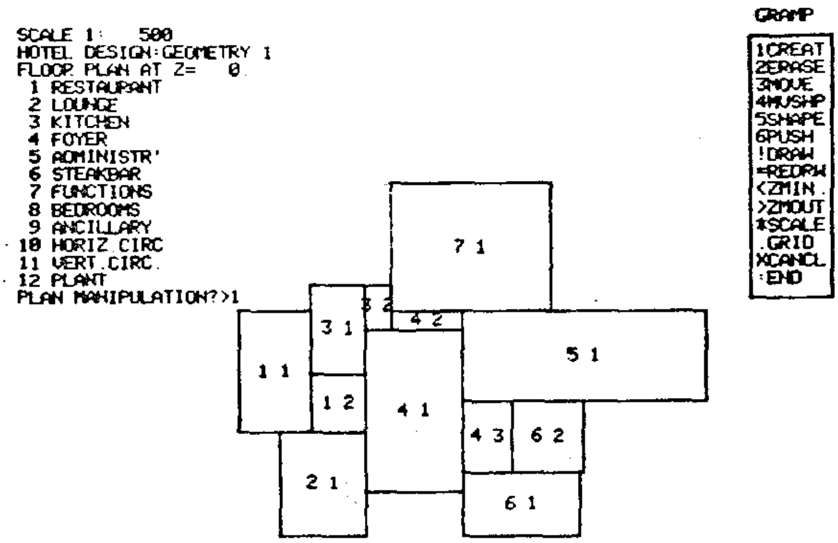

Figure 4 GOAL: floor plan being manipulated on the computer screen

OUTPUT : GENERAL 9-DEC-81 09:19
GEOMETRY : HOTEL DESIGN GEOMETPY 1 GOAL V2.5

AREAS (M2)

COMPONENT		EXT.FLR	INT.FLR	TOT.FLR	EXT WALL	ROOF	VOL(M3)
1	RESTAURANT	147.0	0.0	147.0	78.0	0.0	441.0
2	LOUNGE	109.3	0.0	109.3	78.0	109.3	327.8
3	KITCHEN	75.0	0.0	75.0	36.0	27.0	225.0
4	FOYER	258.0	0.0	258.0	33.0	96.3	774.0
5	ADMINISTR'	270.0	0.0	270.0	121.5	0.0	810.0
6	STEAKBAR	155.0	0.0	155.0	100.5	127.0	465.0
7	FUNCTIONS	252.0	0.0	252.0	129.0	252.0	756.0
8	BEDROOMS	101.3	1410.8	1512.0	834.0	756.0	4536.0
TOTAL		101.3U 1266.3G	1410.8	2778.3	1410.0	1367.5	8334.8

WALL TO FLOOR RATIO 0.51

VOLUME COMPACTNESS 0.55

Figure 5 GOAL: tabulation of functional areas output by the program

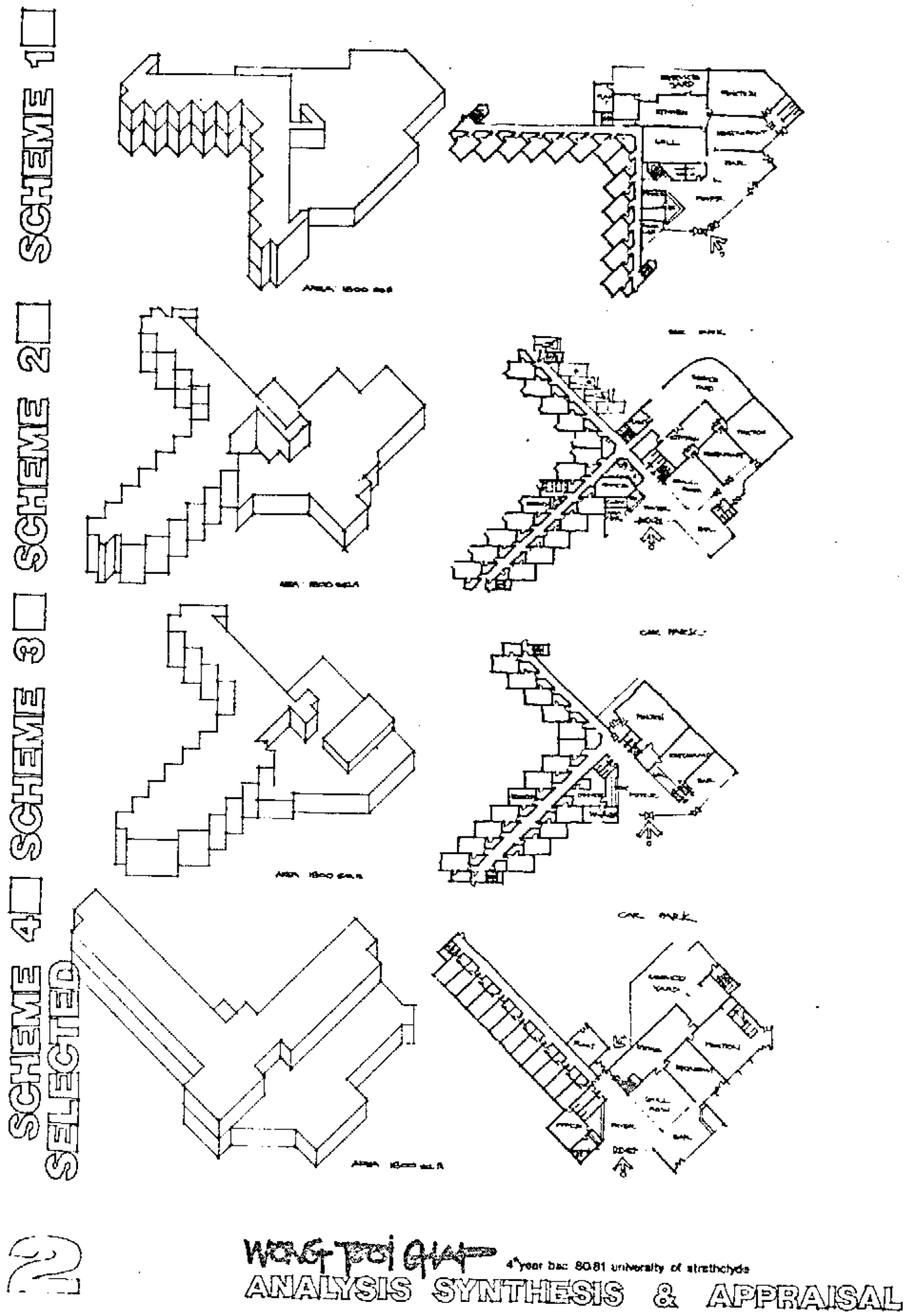

Figure 6 Four alternative hotel geometries compared in terms of a range of cost and performance variables, generated using the program GOAL

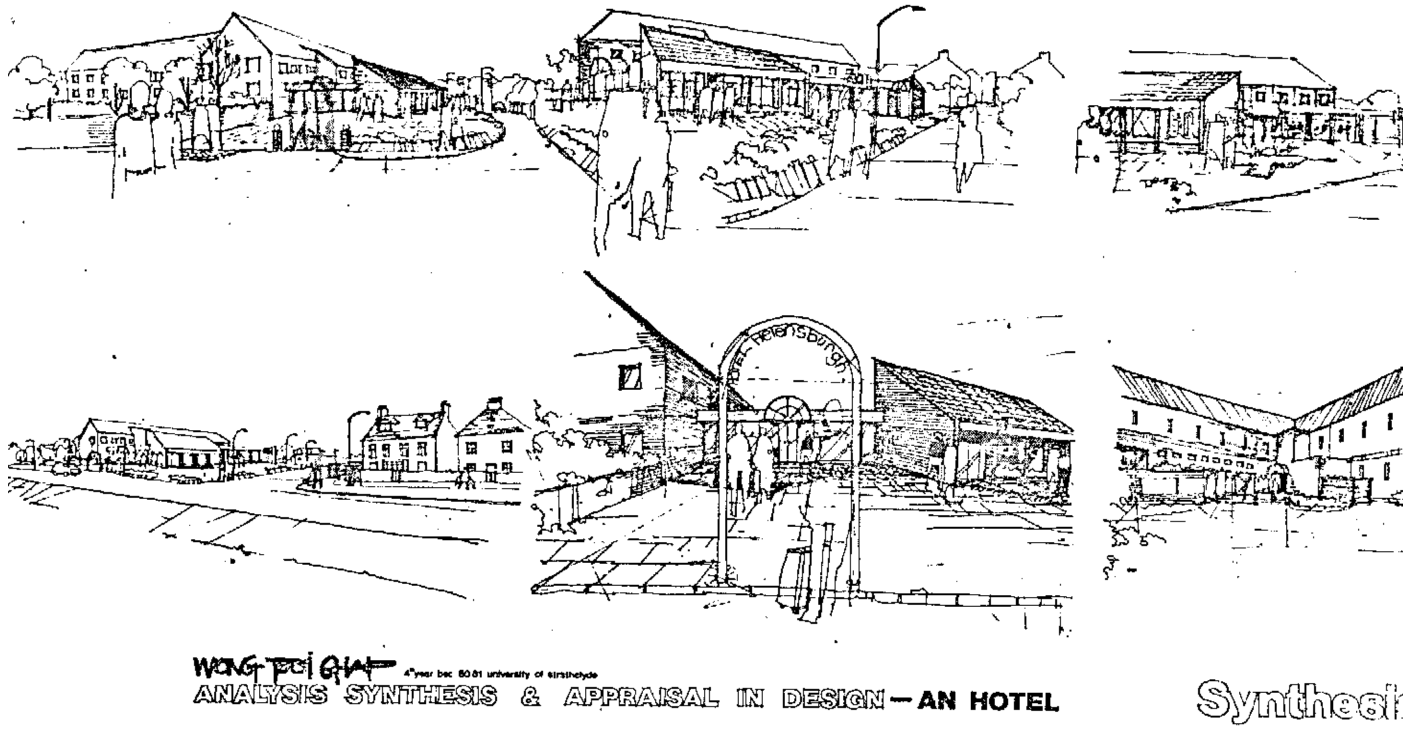

Figure 7. A number of perspective views of the final hotel design, based on output from the program BIBLE

CODE NO	NAMES OF VARIABLES
1	AREA
2	WALL AREA
3	ROOF AREA
4	VOLUM
5	W/F RATIO
6	VOLUM COMP
7	TRAV COST
8	WALL GLAZ
9	ROOF GLAZ
10	ORIEN TION
11	FUEL TYPE
12	HEAT LOSSW
13	HEAT GAINS
14	PEAK ENERH
15	PEAK ENERC
16	ANNU ENERH
17	ANNU ENERC
18	ANNU ENERT
19	LIGHT KW
20	LIGHT ENE
21	COST RUNN
22	COST CAPI
23	COST INUSE

THE CODE NUMBERS OF VARIABLES TO BE STUDIED ?

FIGURE 8. Cost / performance variables stored in GLOSS.

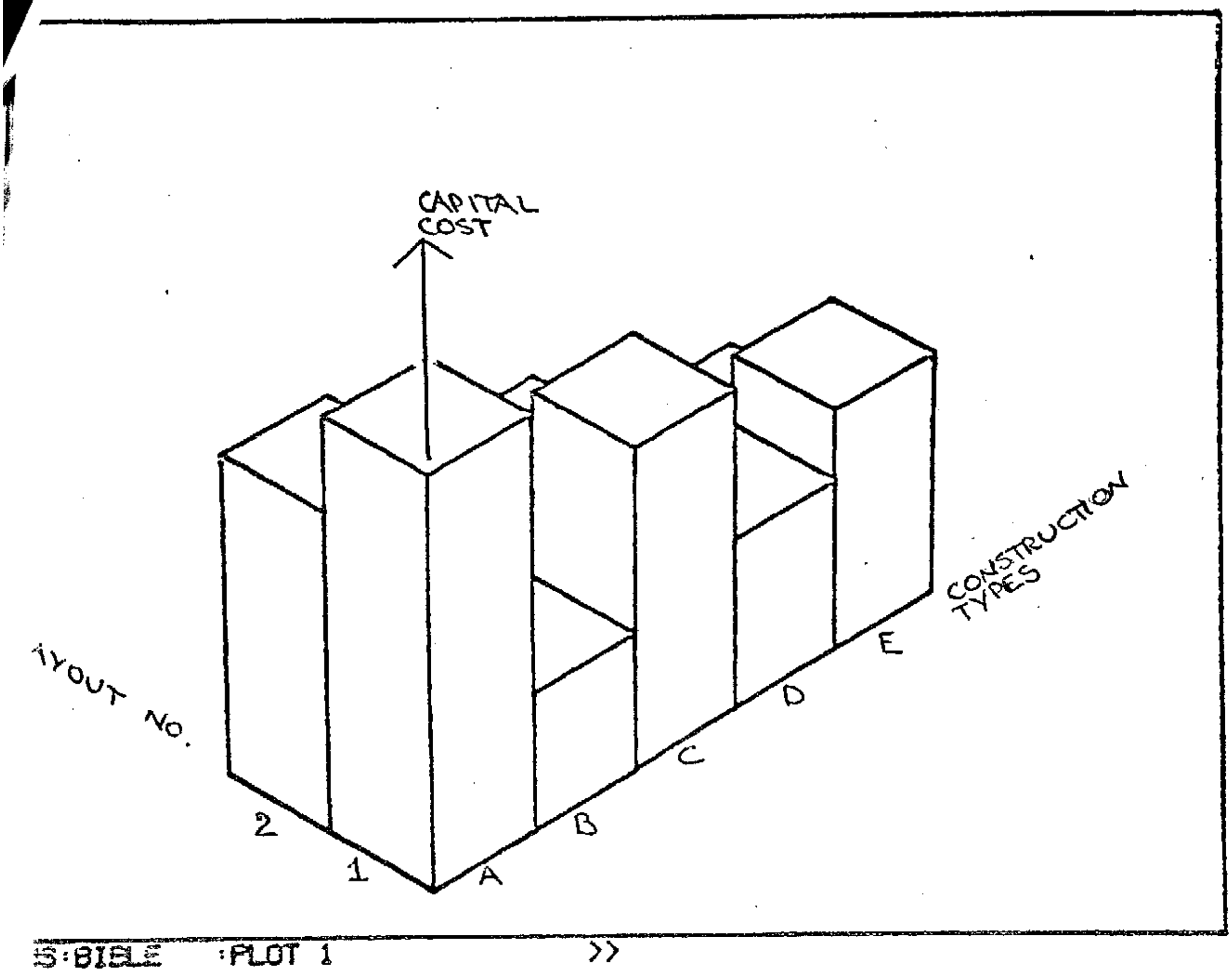

FIGURE 9. 3-D Graph drawn by GLOSS

SCHEME: 1

GEOMETRY HIGH SCHOOL 1
SCHOOL PROJECT CONSTRUCTION 1B
SCHOOL PROJECT ENVIRONMENT 1A

VARIABLES

NO	NAME
12	HEAT LOSSW
13	HEAT GAINS
14	PEAK ENERH
15	PEAK ENERC
21	COST RUNN
22	COST CAPI
23	COST INUSE

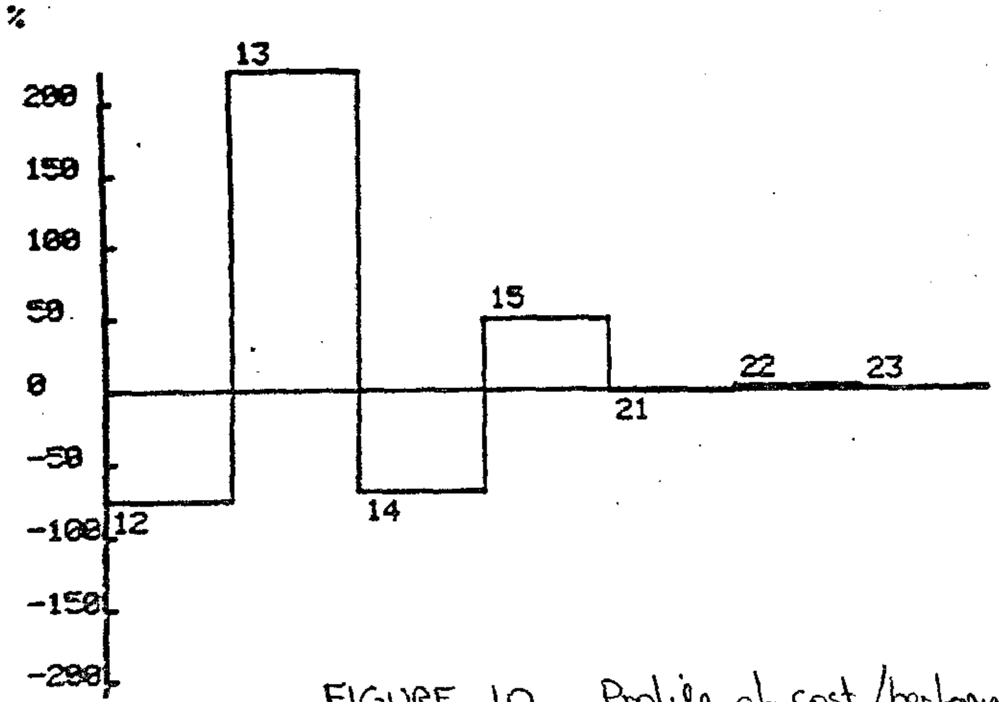

FIGURE 10. Profile of cost/performance attributes.