DESIGN TEACHING:
THE LANGUAGE OF ARCHITECTURAL PLANS

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ABSTRACT
The aims, operation and student reaction to a design studio course for beginning architecture students on the syntax of architectural plans are described. The course is highly structured and draws from computer graphics templates and a teaching manual which set up a series of exercises. The process of learning comes from execution of the exercises and from associated reading, discussion and debate on architectural planning issues.

INTRODUCTION
The question usually posed in relation to computers and the teaching of design is: “How do we use computers in the design studio?” Such a question presupposes an existing structure for teaching design and that the use of computers can be made to fit into that structure. A more appropriate question might be: “How do we teach design in the computing studio?”, in which the teaching of design is made to fit into the nature of the computer medium. Such a question recognises that it is not the hardware, nor the software, but the teacher’s understanding of the nature of the technology and of architecture that matters in developing a pedagogical approach appropriate to a new medium. Given a theoretical basis, teaching with a clear sense of purpose and relative simplicity systems can be very productive. An area in which this is particularly true is in the teaching of design literacy to the beginning (early contact with design teaching) student. This paper reviews the experience of design programs in 1987 and 1988 which have taken this approach in teaching about the nature of architectural plans using computer graphics as the teaching medium.

The medium for teaching is the Macintosh environment, and particularly the MacDraw drawing software. The thematic curriculum encompasses The Elements of Plans (elements and operations); The Concept of Function (function and planning); Order in Plans (order and regulation, and rules and variations); The Taxonomy of Plans (archetypes, composition and plan morphology); Beyond the Plan (plans as mappings of three dimensions); and The Character of Plans (style and attributes in plans).

In this paper we describe the practical implementation of the course, the student response to the teaching approach and the knowledge gained. The philosophy behind the approach and the reasons computer graphics is appropriate as a medium for teaching are described elsewhere.
A SYNTACTIC VIEW OF ARCHITECTURE

The activity of design involves both the interpretation of a set of needs or desired performances in terms of a design, and the composition and transformation of the elements of designs. By analogy with natural language we can regard these operations on form as concerning the syntax of the language of architecture (Coyne and Radford, 1988). The tradition of books such as Durand’s *Partie Graphique* (Durand, 1821) and the considerable recent influence of Ching’s *Architecture: Form, Space and Order* (Ching, 1979) demonstrates a continuing concern with “the essential elements of form and space and those elements that control their organisation in our built environment” (Ching, 1979, p.6). Design theorists such as March, Stiny and Flemming have explored the linguistic analogy through formal shape grammars, and Wojtowicz and Fawcett’s small book *Architecture: Formal Approach* (Wojtowicz and Fawcett, 1986) brings together diverse strands from the syntactic tradition. Studies of the work of individual architects have also emphasised these syntactic compositional aspects, a good example being Baker’s *Le Corbusier: An Analysis of Form* (Baker, 1984).

For beginning students, a concentration on the principles of syntax enables the acquisition of a basic level of competency in the execution of new work and the critical examination of existing work, which is independent of a particular style or language. The students are given design knowledge explicitly and concisely, which is expected to be part of the residual knowledge of their design education. “While utilitarian concerns of function and use can be relatively shortlived, and symbolic interpretations can vary from age to age, these primary elements of form and space comprise the timeless and fundamental vocabulary of the architectural designer” (Ching, 1979, p.6). The context of this design course, then, is a syntactic view of architecture.

THE SYNTAX OF ARCHITECTURAL PLANS

Plans are one of the conventional architectural abstractions by which designers learn to manipulate such formal systems. Designers work with abstractions of designs and syntactic operations take place within one of these abstraction systems. We have, then, languages of design descriptions as well as a language of designs. An interpretation is a statement about designs which belongs to some language other than that whose syntax is defined by the system. A “language of architectural plans” has interpretations in terms of three-dimensional building form, in the same way as a “language of building form” has interpretations in terms of functional performance and social significance. Thus a “Language of Architectural Plans” is different from a “Language of Architecture”. In learning about design, students learn to map between this abstraction and other descriptions of built form as well as learning about making plans within the syntax of the abstraction.

THE SYNTAX OF COMPUTER GRAPHICS

The symbol system of an architectural plan is expressed as shapes and lines, where particular assemblies of lines and shapes have meaning as elements in the language of plans. A computer graphics system maintains the structure of the image as an assembly of entities and allows operations to be carried out on those entities. It also allows the explicit statement of compositional and transformational operations on shapes which is not possible with manual graphics. There is a correspondence, then, between the syntactic operations which computer graphics systems allow on shapes and volumes and the syntactic operations which a designer carries out in the
development of an architectural plan. Mitchell and Liggett, particularly, have explored this correspondence with students over many years in the generation and manipulation of architectural form, and using the correspondence to teach about both computing and architecture (Mitchell, Liggett and Kvan, 1987). In the design of plans, it allows a directness and clarity in the execution of the operations of design which cannot be achieved with manual media. This directness also allows the concatenation of experience through a rapid completion of a sequence of exercises.

A TEACHING COURSE

The aim of the design course is to give students literacy and experience in the principles of architectural planning. The success in achieving this aim should be demonstrated in the future design work of students, although in practice it is impossible to isolate the influence of this from other programs. The essence of the organisation is to manage the educational experience in a much more structured manner than is common in design studios. The teaching manual The Language of Architectural Plans (Oxman, Radford and Oxman, 1988a) is used as a text and followed closely. In terms of tangible results, the aim of the program is for each student to prepare a new and complete set of illustrative examples in response to the exercises in the text. Each of the topics is introduced by a discussion of the issues involved and the intent of the exercise, illustrated by examples of both plans and buildings which demonstrate particular aspects of planning. Students are given a disk containing the "kit" for the course—a set of initial images or "masks" which are manipulated and modified to carry out the exercise (Oxman, Radford and Oxman, 1988b). In 1987 the program was run full-time over ten intensive days, whereas in 1988 it was over five weeks with two sessions each week. Both schedules were successful.

In the following sections we follow the sequence of modules in the course of the program, extracting for illustrative purposes one of the several exercises in each module. Readers are referred to The Language of Architectural Plans for other themes and exercises.

DAY 1: THE ELEMENTS OF PLANS

The first session begins with a discussion of the nature of boundaries in architecture, using slides of buildings or (more often) parts of buildings and their plans. Boundaries can be implied or absolute: a change of level, a line of columns, the implied division by continuing the projection of a wall, the actual boundary of a wall. Plans and images of well-known buildings and townscapes are used to illustrate the sense of enclosure which results, and plans and actual experiences of buildings and external spaces on the University campus are used to reinforce the mapping between plan symbol and three-dimensional form.

The students' work disk contains a plan of the Barcelona Pavilion, set up with boundary elements grouped to facilitate their manipulation: Given a set of graphic elements for the structure and enclosure of Mies van der Rohe's Barcelona Pavilion, make a set of plans which redefine the spatial division and interpenetration of the plan. The students use this exercise to gain familiarity with the graphics system as well as to explore the nature of boundaries. Progress at first is slow, but confidence is gained by seeing the work of colleagues. An essential aspect of the studio is that students work together and learn from each other.

What is immediately apparent is how motivating the computer graphics medium is when used in this way. The ease of execution of the operations, the sense of security because any experiments can be carried out on one of multiple copies of the image, and the crisp quality of resulting prints all contribute to a willingness to experiment and explore.
DAY 2: OPERATIONS

The laser-printed images of the first day's work are spread across a large seminar table and the results discussed over coffee. The sense of a collective discussion, possible if each group is restricted to ten to fifteen students, is important; others join in the discussion from time to time, attracted by the images. The uniformity of the graphics is also important, enabling all to be discussed on equal terms with little diversion into the area of graphic skills which often occurs with manual techniques. The group talks about the sense of enclosure which would be felt in the modified buildings described by these plans, referring back to slides of the Barcelona Pavilion. Suggestions are made to modify some of the studies.

![Diagram](https://via.placeholder.com/150)

**Figure 1. The Elements of Plans: Operations on the boundaries of the Barcelona Pavilion.**

After the review, the discussion turns to the day's topic. The operations of symmetry, translation, reflection and rotation are part of the basic vocabulary of planning operations. Slides are shown of architectural examples which exemplify the operations, such as Utzon's Fredensborg and Elsinore courtyard housing layouts (translation and rotation), the Georgian "circus" terraces of Bath and Edinburgh (radial translation) and Palladio's villas (symmetry). Reading the teaching text ahead of the class, students bring in their own slides or books to show examples they have found.

The day's exercise is set: **Given a set of three or four rectangular spatial elements, make a configuration of these elements. Apply the operations of translation, reflection and rotation on this configuration. Modify the profile of the edges of the set of elements within the same rectangular field and repeat the operations. Modify the new edges to vary the character of the boundaries to closed, permeable and open, and repeat the operations again.**
The studies encompass both the notions of abstraction and levels of abstraction in the plan and the nature of the transformations. As the original rectangles are modified, the way in which the additional information adds to the interpretation is very clear, as is the reduction of possible interpretations when ambiguity is reduced. By now students are taking more care over the production of images. Originally, many tend to produce large-scale images of the kind are "pinned up" on studio display boards in the traditional studio situation. Now, they realise that what is required here is a scale closer to book illustrations than traditional architectural drawings. In the process of learning about planning and abstractions, they also learn about desktop publishing and the design of the image with computer graphics.

<table>
<thead>
<tr>
<th>Three rectangular spatial zones</th>
<th>Profiles within the zones</th>
<th>Boundaries within the profiles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Translation</td>
<td>![Translation Diagram]</td>
<td>![Boundary Diagram]</td>
</tr>
<tr>
<td>Glide Translation</td>
<td>![Glide Translation Diagram]</td>
<td>![Boundary Diagram]</td>
</tr>
<tr>
<td>Rotation</td>
<td>![Rotation Diagram]</td>
<td>![Boundary Diagram]</td>
</tr>
<tr>
<td>Reflection 1</td>
<td>![Reflection Diagram]</td>
<td>![Boundary Diagram]</td>
</tr>
</tbody>
</table>

*Figure 2. Operations: Transformations to fields, edge profiles and boundaries.*

**DAY 3: THE CONCEPT OF FUNCTION**

The view of function explored in this program is syntactic, in which defined functional entities are configured in space. One way to conceive of a plan is as a particular two-dimensional relationship of activity areas, and one approach to planning is to work with activity areas as if they were spatial cells. The aim then is to achieve a spatial configuration which satisfies the goals of the problem. Various books and standards provide the spatial requirements of activities and
equipment, and these can be translated into planning modules by treating physical elements as the “core” of the module, and the space they require around them as the “field”. For example, a bed would be the core of the sleeping module, with the space required around it to make the bed, as the field. Learning to combine or “pack” functional elements is an essential paradigm in architectural planning.

The student work disk contains a vocabulary of such modules with “core” and “field”: Given a set of graphic entities representing furniture objects (core) and their associated access zones (field), make a plan containing the furniture and access necessary to fulfill the function of a motel room with (a) minimal space standards (overlapping fields) and (b) more generous space standards. Bound the furniture arrangements by the enclosing elements (wall and windows) of a room. Given the resulting room as a planning entity, make a plan arrangement for the whole or part of a wing of a motel. It is an exercise which many an architect has carried out using cut-out pieces of paper or card, but the computer graphics medium again clarifies the operations.

Figure 3. Function: Designs for a wing of a motel

DAY 4: ORDER AND REGULATION

The role of geometry, proportional systems and regulating lines has been of symbolic as well as practical significance throughout the history of architecture. In the Ecole des Beaux Arts, systems of architectural planning were developed which were based upon axial organisation and the hierarchical accommodation of spatial volumes in the axial scheme. Recently, the design principles underlying the formal systems in the work of Palladio and Wright have been defined as “formal grammars” or languages of design, and the discussion at the beginning of the day includes Stiny and Mitchell’s shape grammar for Palladian villas (Stiny and Mitchell, 1978). The understanding of this complex subject requires study; here we merely suggest certain basic concepts.

The exercise is simpler: Given a four-by-four grid, develop a set of boundary elements to inhabit the grid. Make several variations of the arrangement of the elements and erase the grid.
Figure 4: Order and Regulation: Plans on a four-by-four grid.

One of the most well-known and influential articles on the idea of underlying order is Rowe's analysis of the Palladian and Corbusian applications of nine-square plans (Rowe, 1976) and the type has been the basis for design experimentation in the work of Graves, Eisenman, Meier and European architects such as Botta. There is a tendency to over-complication in the way students approach the exercise, a belief that the exercise must demand a not-quite-understood sophistication in image. The realization that the best results can come from an acceptance of, and a working within, the discipline of order is an important lesson.

DAY 5: RULES AND VARIATIONS

Implied within the idea of ordering systems is that of rule-generated design, including the flexibility of achieving variations within an underlying order. Learning about order, rules, and variations is part of the basic training of the architect. Today's exercise emphasizes the rules: Given the vocabulary of planning elements and rules for joining those elements developed in Utzon's Espansiva Byg project houses, make some plans within this language of modular housing. The exercise follows the linguistic analogy exemplified in the writing on shape grammars, and the discussion session includes not only Utzon's work but an extensive review of Frank Lloyd Wright's language of the Prairie House and its encapsulation in Koning and Eisenberg's shape grammar (Koning and Eisenberg, 1981). In previous years we have asked students to execute this grammar directly. The idea of variations implies that something is maintained as a constant while certain design variables are modified, thus creating the variations on a plan. These changes come about as the result of certain kinds of operations which occur while maintaining the essential properties of the plan.

Figure 5. Rules and Variations: Designs in the language of Utzon's Espansiva houses.
DAY 6: ARCHETYPES

Certain primitive, or diagrammatic, forms of organisation in plan can be regarded as prototypes, or source types, which carry the seeds of many variations and generations. The prototype, archetype or, simply, type is the subject of much discussion in architecture today. There is also much theoretical debate devoted to the significance of these terms. Typology constitutes an important kind of disciplinary knowledge in architecture; it is knowledge at a fundamental level and at a high level of generalisation, about certain configurative classes of plan organisation. It is exemplified in Clark and Pause’s book (1985) on precedence in architecture, and the discussion ranges over the use of precedence over time. The exercise takes a particular archetype: Given a plan of Hejduk based on the themes of parts and wholes, redesign the plan using the same elements.

Figure 6. Archetypes: Plans based on a plan by Hejduk.

DAY 7: COMPOSITION

We have already mentioned how much attention was given to the subject of composition in the Ecole des Beaux Arts but, until very recently, it has been generally neglected in modern architectural education. This was perhaps due to the association of the subject with predetermined solutions, and the desire to avoid such formal constraints in the generation of unique plans. Composition has the connotation of preconceived types which was antithetical to the tradition of the new. It furthermore implied completed and ordered forms, and had the taint of aestheticism. A
more ideologically acceptable term was that of organisation. Attention to the subject with respect to both architectural and urban form was one of the great contributions of Team X; the application of mathematical tools to form and configuration by March and others opened a new understanding of architectural and urban form. The exercise is deliberately open, an opportunity for free experimentation after the discipline of the preceding series: Expressing aspects of order and regulation, rules and variations, and archetypes, compose a pair of plans for the fabled King's and Queen's Palaces of Kubla Khan.

Figure 7. Composition: The palaces of Kubla Khan.

DAY 8: PLAN MORPHOLOGY

A classification into morphological classes should result in a smaller number of larger classes than by distinguishing each function as a building type since certain building functions, such as a dormitory and a hotel are morphologically similar. Some of the morphological classifications which we might make are:

Repetitive Functions: The dominant element is repetitive as in housing or motels.
Non-repetitive Functions: A mixture of various spatial scales as in social centers and museums.
Focal Orientation: Theatre or auditorium.
Technical Interface: Hospital, factory or airport.

Spatial morphologies are a level of generalisation which assist in learning paradigms of planning, since each of the morphological classes has particular design procedures associated with it.

Paradigmatic: Morphological classes common to several functions.
Functional Domain: General knowledge, particular to a specific function such as housing, and a further level of specific subclasses such as row housing.
Procedural Knowledge: Specific knowledge of procedures for dealing with specific, but recurrent constraints and situations in functional domains, such as limitations of frontage, or steep slopes.
The exercise is: Make three designs which symbolise the three plan classes of house, laboratory and center.

The House - a series of repetitive spaces. In this case the organisational principle is defined as "pure form" - additive linearity.

Laboratory - a unit that functions with specific technological items. An hierarchy of these spaces is set up and repeated.

The centre - a complex dictated by its circulation space whose axis meet to indicate the main area.

Figure 8. Plan Morphology: House, laboratory and center.

DAY 9: PLANS AS MAPPINGS OF THREE DIMENSIONS

Part of the aim of this course is to teach about the mapping between the shape and edges of the elements of a plan and the volumes and surfaces of the elements in a building. The elements of the plan of a Gothic building look very different, and suggest a different three-dimensional form to the elements of a plan of a Renaissance building. Certain shapes on a plan suggest certain volumes: boundaries configured in a circle suggests a dome, a small circle suggests a column, a thick line suggests a heavy masonry wall, and a thin line suggests glass. Consider, for example, Bramante's plan of St Peter's in Rome as an expression of the dome, vaults, columns and piers of the building. The opportunity is used to show, discuss and compare numerous examples of plans, physical three-dimensional models and completed buildings. The exercise is constrained in order to use the MacDraft environment: Given a plan, transform the plan by projection of the elements and boundaries to make a representation of its three-dimensional form.
DAY 10: STYLE AND ATTRIBUTES IN PLANS

Style in Simon's (1976) terms is a "way of doing things". An historic style is a complex phenomenon denoted by a wide range of diverse factors such as building technology, building types, spatial characteristics, and various formal indicators. In the context of planning, it may be germane to focus upon formal indicators and to consider them, in the light of Simon's definition, as formalized processes of planning. The exercise is intended as a culmination of the program, bringing together the diverse strands of the preceding topics: Construct the plan of a well-known building. Make a plan for a small extension to the building which encapsulates the style and attributes of the plan.

Figure 9. Plans as Mappings of Three Dimensions: Spatial compositions

Figure 10. Style and Attributes in Plans: An extension to Aldo Van Eyck's children's home in Amsterdam.
In the first year of running the program, the purpose of constructing the plan was not revealed until after it was completed. Using this strategy, the thought that had been given to, and the understanding that had resulted from, the process of constructing (not tracing, and certainly not electronically scanning an existing image) could be reviewed and discussed prior to the drawing of the extension plan. In this second year, students were asked to draw one of Frank Lloyd Wright’s Usonian houses and add a small extension, knowing the purpose of the exercise beforehand. This did not seem to detract from the value of the drawing process.

CONCLUSION

The work produced by the students in the prototype studio (some examples are reproduced in this paper), and their enthusiasm both during and after the program, suggests that a highly structured program of this kind can be of considerable benefit. Certainly the students themselves have been enthusiastic. It seems that both the “less able” and “very able” in design can gain from the opportunity to concentrate on some specific aspect of syntactic design and explore that aspect in more depth than is usually possible. The use of microcomputers and the exercise “kits” supports the structure. They also enable students to produce a high quality of graphic image, and ensure a consistency of crisp image quality from student to student. This enables the teacher to concentrate on the manifestation of the knowledge which the exercise is intended to impart, rather than manual drawing skills in expressing that knowledge, and to compare the ideas of different students on equal terms.

REFERENCES