TEACHING SPACE SYNTAX THROUGH REFLECTIVE PRACTICE

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Abstract

At previous space syntax symposia discussions have arisen as to the best way to use space syntax methods as a teaching tool at undergraduate and postgraduate level. Using the example of the first exercise given to students on the MSc Advanced Architectural Studies at the Bartlett, UCL, we will present our experience in teaching space syntax as a tool for investigating the relationship between spatial configuration and social form to students new to the field.

Since teaching the computer-based analytic tools has to be grounded in a real understanding of what space syntax is about, a project was developed that involved students working together in small groups of four, with each group studying and comparing four carefully selected examples of 20th century 'classic' modernist housing, so that to successfully complete the exercise the students needed to work individually on analysing a specific house and together to share and compare results, thus learning from one another. The formal teaching involved a theoretical grounding in space syntax 'decoding' of domestic space, coupled with practical workshops on hand-drawing and hand-calculations of the basic space syntax modelling tools: axial maps, convex maps and justified graphs, visual fields etc. through which we introduce concepts such as configuration, interface, privacy and permeability.

By teaching through action learning, with students taking on their own analysis of what is arguably the most complex building type, we propose that these kinds of modelling analysis projects are an ideal vehicle for taking architects from where they are at the start of the course, with an intuitive understanding of built form, and helping them to build on that foundation towards an understanding of scientific research in general and space syntax analysis in particular, so that they can become reflective practitioners of this complex research field.

Advanced Architectural Studies at UCL

The MSc Advanced Architectural Studies (AAS) at University College London (UCL) has been running at the Bartlett School of Graduate Studies for over 30 years [i]. Since its foundation, teaching on the course has stemmed from the space syntax research program, which also originated at the Bartlett. The 12-month program comprises four

core modules, which together with the final 12,000 word thesis; aim to provide basic grounding in a scientific approach to architectural research. The four modules - Theory of Architecture and Urban Space, Urban Transformations, Architectural Phenomena and Principles of Spatial Morphology - are taught in parallel during two teaching terms, followed by the thesis, which is supervised from May to September.

This paper focuses on the teaching of the Principles of Spatial Morphology (Principles) module, describing a group exercise that the students undertake during the first five weeks of the course. After a description of the exercise, we will discuss the challenges in taking the students from their existing intuitive understanding of built form towards an understanding of scientific research, so that they can become reflective practitioners (Schon, 1983) of this complex research field. We will then explain the difficulties in teaching the increasingly sophisticated computer modeling techniques, with their high levels of abstraction, without losing the students' contact with the real architectural world. After presenting the learning experience from the students' point of view we will briefly discuss the main findings that emerged from the exercise. The paper ends with conclusions about the applicability of this teaching exercise for the wider architectural teaching community and the lessons that can be drawn from it for the space syntax community as a whole.

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The Principles of Spatial Morphology Exercise - Decoding Architects' Houses

The Decoding Architects' Houses exercise involved groups of four students in a collaborative study of individual houses by major 20th century architects, chosen from a pair of books by Dunster (1985, 1990) on key twentieth century houses. Four seminal houses by leading architects were chosen for each group to study, according to various built form themes that were likely to appeal to architectural students (Table 1). We stress the importance of quite careful choice of examples so that we knew that there was an interesting research question to explore before the students started their project.

Table 1:

Base data for the case studies selected for group analysis

Theme	Example	Date	Architect	Location
Concrete Cubes	House, Luxembourg	1974	Rob Krier	Luxembourg
	Horiuchi House	1978	Tadao Ando	Sumiyoshi, Osaka, Japan
	House at Ligornetto	1979	Mario Botta	Ligornetto, Switzerland
	House VI	1976	Peter Eisenman	Cornwall, Connecticut, USA
Glass Boxes	Farnsworth House	1945	Ludwig Mies van der Rohe	Plano, Illinois, USA
	Wiley House	1953	Philip Johnson	New Canaan, Connecticut, USA
	House at Hellebæk	1953	Jorn Utzon	Hellebæk, Denmark
	House at Bingie Point	1985	Glen Murcutt	Moruya, NSW, Australia
Breaking Out of the Box	Mother's House	1962	Robert Venturi and John Rauch	Chestnut Hill, Philadelphia, Pennsylvania, USA
	House at Creek Vean	1966	Team 4	Feock, England
	Own House	1978	Frank Gehry	Santa Monica, California, USA
	Athan House	1989	Maggie Edmond and Peter Corrigan	Monbulk, Melbourne, Australia

The aim of the exercise was to represent a small house as a space configuration in a clear and consistent way, such that the representations capture and pinpoint key characteristics of its built form and space organisation. The descriptions were carried out to a standard format – with 16 set tasks, so that direct comparisons could

be made between identical representations of different houses. Each member of the four-student group was responsible for analysing 1 of 4 cases and together they were responsible for making a comparison between them in an audio-visual presentation at the end of the exercise.

The choice of domestic space was made for various reasons. Whilst exercises assigned later in the course may involve either theoretical modelling or technicality of some kind, for the houses the students are forced to consider the social dimension as well as the built form. The house programme is clear: it is to function as a home. The students can immediately imagine what it would be like to inhabit and use the space. And as soon as they have made that sort of transition to imagining themselves within that spatial configuration, the students can no longer remain neutral about it but are encouraged to reflect on and critique the design and layout of the house in the light of their previous knowledge and evolving understanding of configuration.

An interesting aspect with this exercise is that the students work in a group of four, which seems to work year-on-year in creating very good group dynamics. Lawson (1990) has drawn attention to the benefits that designers can derive from working in teams to 'hammer out' their ideas, but we have found that there may be drawbacks as well as advantages to working in groups. For example, in previous exercises where students have studied a large cultural building such as the British Museum, the most technically-proficient students often assumed responsibility for the computer modelling on behalf of their entire group, so that not every student had an opportunity to learn the relevant procedures. This negated many of the pedagogic objectives of the learning experience.

The exercise was supported by three teaching modes (as well as group tutorials with two doctoral students who acted as teaching assistants): workshops for teaching the practical aspects of spatial modelling and calculation; lectures on the scientific theories and experimentation; and theoretical seminars on theories and research into domestic space.

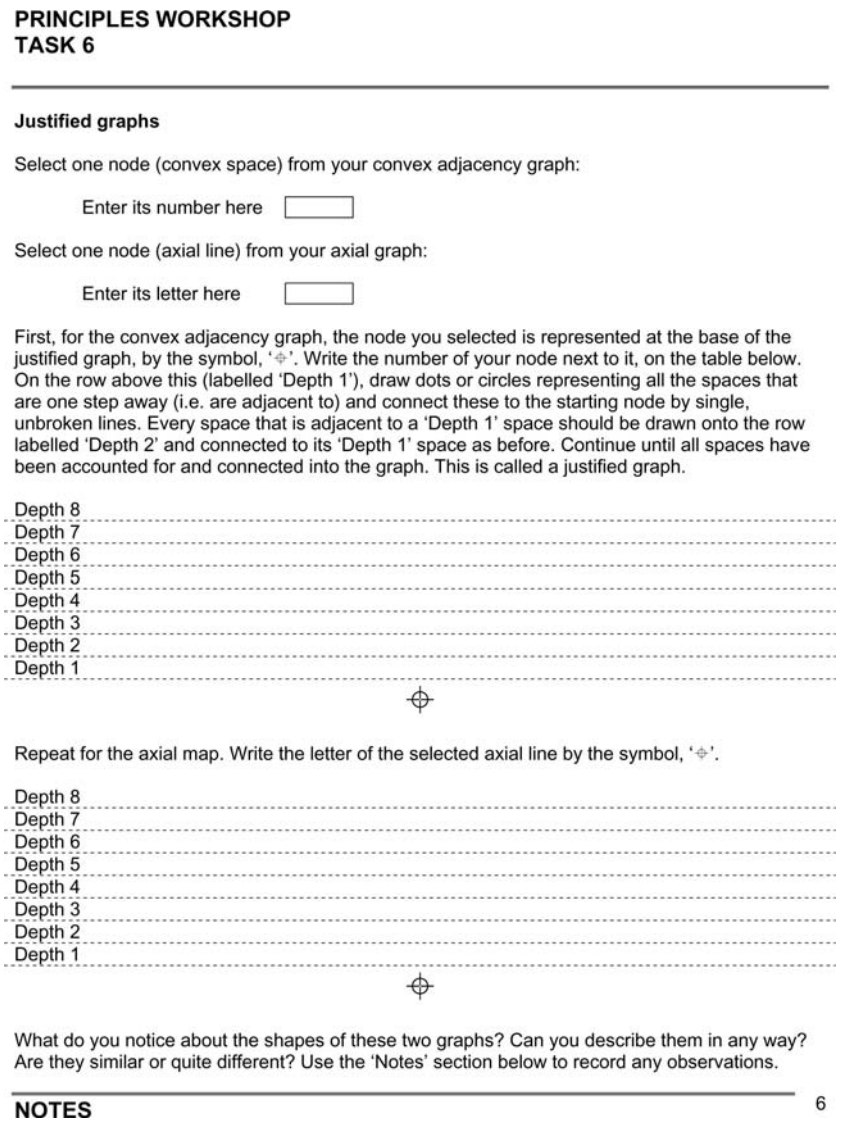
Workshops

The exercise tasks were taught in highly structured group workshops. The workshops comprised 16 exercises, which reflected the tasks the students were subsequently required to execute on their own houses. All the floor plans, diagrams and calculation-forms were pre-prepared in the form of a bound 'workbook' so that the students could subsequently check their work against the 'correct' example (Figures 1-2 [ii]). The exercises were spread across two two-hour workshops – on 'Observing and Representing' [iii] followed by a second workshop on 'Transforming & Calculating' [iv] (Hacking, 1983). It was striking that the students had the greatest difficulties in the conceptual stages of the Observing and Representing tasks.

A single building was used as the spatial setting for all tasks so that the students could readily comprehend the process of incrementally constructing a complete dataset, as well as the interrelation between the different stages of the process, in particular to be able to grasp the ways in which certain tasks fed into later ones and how each of these became the 'building blocks' of the final dataset. The university building in which the teaching took place was used as the spatial setting for the exercises so that the students could be situated in and check for themselves (ground truthing [v]) if their drawn representations reflected the experiential reality of using the building.

Figure 1:

Task 6



PRINCIPLES WORKSHOP
TASK 6

Justified graphs

Select one node (convex space) from your convex adjacency graph:

Enter its number here

Select one node (axial line) from your axial graph:

Enter its letter here

First, for the convex adjacency graph, the node you selected is represented at the base of the justified graph, by the symbol, '⌖'. Write the number of your node next to it, on the table below. On the row above this (labelled 'Depth 1'), draw dots or circles representing all the spaces that are one step away (i.e. are adjacent to) and connect these to the starting node by single, unbroken lines. Every space that is adjacent to a 'Depth 1' space should be drawn onto the row labelled 'Depth 2' and connected to its 'Depth 1' space as before. Continue until all spaces have been accounted for and connected into the graph. This is called a justified graph.

Depth 8
Depth 7
Depth 6
Depth 5
Depth 4
Depth 3
Depth 2
Depth 1

Repeat for the axial map. Write the letter of the selected axial line by the symbol, '⌖'.

Depth 8
Depth 7
Depth 6
Depth 5
Depth 4
Depth 3
Depth 2
Depth 1

What do you notice about the shapes of these two graphs? Can you describe them in any way? Are they similar or quite different? Use the 'Notes' section below to record any observations.

NOTES 6

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The first of these tasks, the observation task required the students to move around and 'inhabit' all of the public spaces in the building in order to answer the following questions: "Is this private or public space?" "When occupying a space, does this feel like one space or more than one space?", "Which are the most significant lines of sight?", "What objects occlude these lines?" and "Are occluding objects temporary or permanent?" The observation task was followed by a number of exercises in which the students were then expected to represent the spatial configuration of the building using standard space syntax methods of subdividing all navigable space into discrete spatial units. As described above, this was the stage that caused the greatest difficulties for the students, as it is the stage that particularly differentiates novice from experienced practitioners. Based on our experiences, we therefore recommend a minimum ratio of 1:4 for teaching assistants to students in order to handle disparities of understanding amongst a typical student cohort.

Theory Lectures

In parallel to the two workshops, were two associated lectures. The students were first introduced to the question, 'What is scientific theory?' which presented a range of models of the process of scientific enquiry. Presented in chronological sequence, these included descriptions of the contributions of Aristotle, Descartes, Hume, Bacon, Popper and Hacking. These descriptions of models of scientific method were set against the question of what is architectural

research and a discussion of the unique problems associated with architectural research. A useful, practical task that was included as part of this lecture was for each student to state their initial focus of interest in their house (under study) and to re-phrase it as a single-sentence research question. This was conducted as a round-the-table exercise.

PRINCIPLES WORKSHOP
TASK 16

Ranking and banding

Rank the spaces, from the table in task 15, according to their integration values (high to low)

Room	Integration value

Divide the list you have made into five bands, according to the range of integration values.

These values below should help you decide which spaces fall into which band.

Max value (from task 15)

Min value (from task 15)

Range (max – min), R

Range ÷ 5 (R/5), interval, i

Band 1 upper bound (max)

Band 2 upper bound (max – i)

Band 3 upper bound (max – 2i)

Band 4 upper bound (max – 3i)

Band 5 upper bound (max – 4i)

Band 5 lower bound (min)

Go back to your original convex break-up map (task 2) and colour the convex spaces according to their colour band.

Band 1 (upper quintile) = red
Band 2 (upper middle quintile) = orange
Band 3 (middle quintile) = yellow
Band 4 (lower middle quintile) = green
Band 5 (lower quintile) = blue

NOTES

16

Figure 2:

Task 16

As a consequence of this lecture, when the students were introduced to the workbook, they were presented with the sixteen tasks as a sequence of exercises: observation tasks, exercises of creating representations of the study-building, transformations of the data from one form of representation (e.g. the axial map or the convex space break-up) to another form of representation (e.g. the justified graph), and then, finally, performing a series of calculations (e.g. descriptive statistical calculations as well as basic space syntax measures). By completing the workbook, the students had explicitly replicated the process of observation, representation, transformation, calculation and then interpretation that they had just learnt about in the accompanying lecture. The strength behind the pairing of this lecture with the workshop was that they were given the opportunity to perform these tasks, with the knowledge of the source of these ideas, and were able to directly reproduce the process within a short time of learning about it.

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The second accompanying lecture was on elementary building descriptions, on the idea of space syntax representations being 'embodied diagrams [vi]'. The idea behind an 'embodied diagram', is that the spatial representations used in space syntax are not just a convenient shorthand used to discretize a spatial system but that they are, in themselves, meaningful representations, containing manifold interpretations, particularly associated with the experience of being situated within a spatial milieu (Figures 3-4).

Figure 3:

The spatial representation, axial line, as an embodied diagram

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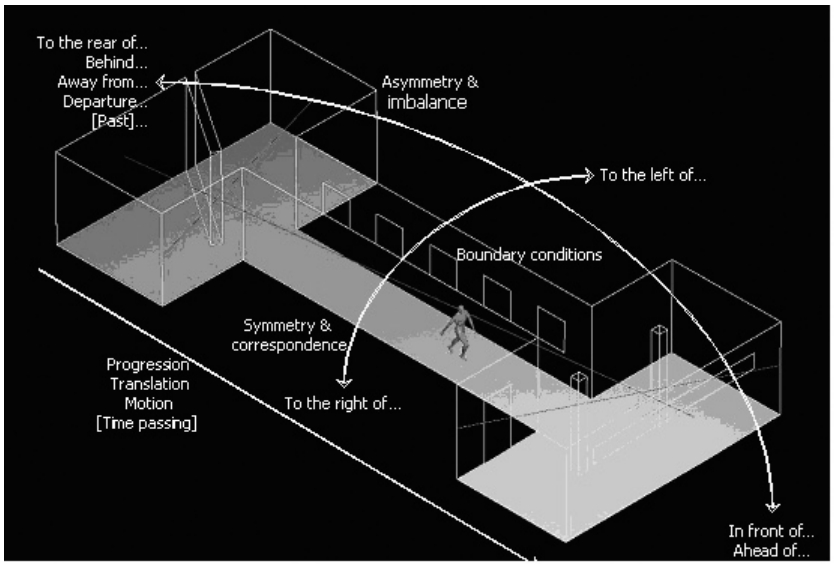
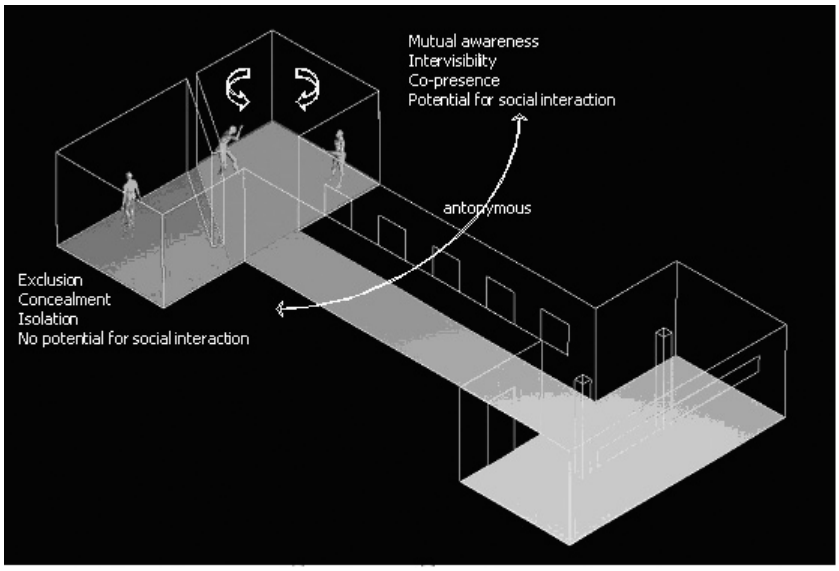


Figure 4:

The spatial representation, convex space, as an embodied diagram



This lecture was particularly relevant to the initial task of the workbook, which was the observational task where the students were asked to move around the building, to inhabit the spaces and to think about the nature of the spaces they occupied. Having already received this lecture, about the range of possible meanings with which space syntax representations are imbued, when the students came to draw these representations, they were not simply drawing lines on paper; they were drawing lines that were highly meaningful to them and which pertained directly to the experience of being within that particular space.

We believe that the timing of this lecture was crucial, because we have noted that one of the things that students find quite difficult, at the start of the course, is understanding that space has a dimension

that is measurable. This lecture helped the students to understand how to approach the construction of spatial representations such as axial lines and convex spaces. The students were able to actually understand that what they draw is about what they can see and what they can see is the space which they are occupying. They are not purely going through the motions of drawing a graph, that it to say, simply creating a representation. They are actually thinking it through as they are doing it.

Theoretical Seminars

Alongside the workshops, the students participated in three seminars that established some underpinning principles for 'decoding homes and houses' (Hanson, 1998) in order to ground what the students were doing in relevant architectural, social and spatial theories. Each seminar was based on a pair of foundation texts, one of which was a chapter from Hanson (1998) and the other a reading from the wider literature on domestic architecture.

The first seminar considered the fundamental relationship between 'house form and culture' as expounded in Rapoport's (1969) seminal book of the same name. The two dominant explanations of house form at the time when Rapoport was writing were those of 'physical determinism', which asserted that house form is determined by a single dominant variable (climate, materials, site, defence, economics or religion) and the philosophy of 'basic human needs', which attributed house form to shared, universal human needs (shelter, territory, privacy). Set in this context, Rapoport's proposition that houses are primarily shaped by socio-cultural forces such as family structure, symbolism, gender, or privacy, and are only then modified by climate, construction, materials and technology appeared to be quite radical. Specifically, Rapoport proposed that houses are the physical expression of the genre de vie (way of life) of a particular society. Hanson's (1998) study of seventeenth century Banbury houses was then presented as a worked example of genre de vie, in that the climate and technology of the region remained unchanged throughout the century, whilst the spatial configuration of the houses appeared to respond directly to momentous changes that were occurring in the social, political and religious values of the time.

The second seminar guided the students through a series of concepts, starting from the distinction between a 'functional' and a 'phenomenological' approach to domestic space. The former stresses the behaviour of the user, is concerned with the physical properties of a space, and describes a way of living from the viewpoint of an external observer. Housing design guidance usually takes this form. The latter emphasises the experience of dwelling, is concerned with capturing the qualities of a space and takes an existential viewpoint in that it describes the way of being of an experiencing subject. The students were introduced to Levi Strauss' (1966) 'culinary triangle' and Wood and Beck's (1994) proposition that the layout of a domestic living room can be understood as an instantiation of a kind of collective memory. The list of rules generated by Wood and Beck's study of a typical American living room was contrasted with the proposition that a 'space code' can be understood as a set of transformations on an underlying structure (Bernstein, 1971). Two empirical research studies of post-war housing formed the evidence-base for the seminar; Lawrence's (1987) comparison of the layout and domestic routine of two samples of Australian and English post war homes and Hanson's (1998) study of the 'gentrification' of London terraced houses in the 1960s and 1970s. These studies were utilised to illustrate how houses can encode cultural and class differences in their spatial configuration and in the material culture of the home.

The third seminar introduced a final case study that represented the collective work of a group of AAS students from the 1990s, which gave rise to intriguing speculations about how architects houses may be similar to or different from those of speculative developers or house builders. The comparative reading was taken from Serge Chermayeff and Alexander's (1963) Community and Privacy, which was selected because of its relevance to housing design and the design of whole communities. This student project, which was the precursor of the one which is reported here, undertook an analysis of post-war family houses built in London by architects for their own use. It established that the architects' London houses bore the stamp of popular values, but that their morphology revealed a richer array of configurational possibilities, greater spatial investment in articulating relationships among family members and to visitors, and greater investment in the nature / culture relation through connectivity to exterior spaces than could be found in contemporary speculative housing. An important finding that emerged from the study was that the major rooms in the architects' homes took the form of large, articulated spaces, each made up from several smaller and larger convex elements combined together in such a way that a 'privacy gradient' was established from an integrated core of spaces to a set of deeper, more segregated, quieter and more private parts of the home. These ideas bore a strong relationship to Chermayeff and Alexander's propositions about how to manage the relationship between community and privacy in a well-designed family home.

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At the same time, a strong message to emerge from the 1990s study of architects' London houses was that there was more social continuity between the architect-designed and the contemporaneous UK homes designed by speculative house builders than Rapoport had allowed for in House Form and Culture, where he argued strongly that modern architects have lost touch with their vernacular roots. Rather, the evidence from the London study suggested that it would be unsafe to assume a radical discontinuity between the architectural profession and society at large. Though architectural education seeks to induct young architects into a set of shared values and practices, these may still bear the imprint of 'social knowledge' (Hillier, 1996: 42) and it may therefore be harder than one imagines to break free of pre-structures to create a totally original design solution, even when encouraged to do so by teachers and design tutors. With these insights, the students were forearmed against making unwarranted assumptions about the houses they had allocated for the Principles exercise.

Student Presentations as Reflective Practice

Towards the end of the exercise the students had a group tutorial on formulating their research questions. They were then left to work on their own, with each group having to put together a 30 minute audio-visual presentation on their findings and the conclusions from their analysis. They were asked to make a commentary in which they highlighted the main points of their analysis, and the research question they had developed, interpreting the evidence in the light of the guidance we had given in the workshops, seminars and lectures.

Although the 'low-tech' approach would have also worked – where the students could have printed off their findings and put them on the wall, we believe that the advantage of an audio-visual presentation is that the students were forced to choreograph their presentation ahead of time. We suggest that the preparation of the presentation can, in and of itself, encourage the students to reflect on the learning process they had undertaken. They will have learnt from each other what worked better and what worked less well and the oral presentation, which in subsequent assignments is always a precursor to a written paper, will

have acted as a useful rehearsal on how to organise findings in a logical order in order to gain the greatest benefit from the work.

From Intuition to Descriptive Analysis

An important aspect of the Principles exercise is that it is grounded in the students' previous experience because they have all lived in houses. In addition, architecture students in many schools of architecture are encouraged to study seminal houses by famous architects in order to understand basic principles of good design. In this respect, most students are already familiar with the discourse of conventional architectural criticism. Furthermore, quite often students at this stage in their career have either been commissioned to design small houses of their own or have supported senior colleagues in so doing. We can therefore safely assume that the students have some appreciation of the concept of dwelling and housing, and therefore we are starting where the students already have some understanding of the issues. This is quite important because we want to harness their intuition in order that the exercise that we set is always more than a technical exercise and that it also contains a theoretically interesting set of challenges to explore. In this respect, they are not just learning to 'do' space syntax but rather learning to 'use' space syntax as a means to answer intelligent questions.

Another dimension of the teaching approach adopted for this exercise is that since most of the students have come from architectural design background, they are used to assimilating knowledge intuitively, and also to 'learning through doing'. In this sense, architecture teaching has for many years been at the forefront of educational theory because it has always been practice-based learning. The design process has been characterised by Schon (1987) as 'reflection-in-action' and indeed he holds up the architecture studio to teachers in other academic disciplines as the educational model for all active learning. Schon's seminal work on the dynamics of teaching and learning in the design studios at MIT has influenced a generation of educationalists, but from our point of view the fact that all architectural students are used to learning in this way meant that the first exercise on the AAS course was in a learning mode that was familiar to the students from their previous studies.

Teaching and learning in architecture is also a paradigm case of 'experiential learning theory' (Kolb, 1984). This can be defined as a mode of learning in which knowledge results from a combination of grasping and transforming experience in a four phase virtuous learning cycle that comprises concrete experience, reflective observation, abstract conceptualisation and active experimentation. Kolb's theories have transformed teaching in a wide range of university disciplines including management, computer science, psychology, medicine, nursing, accounting and law.

Kolb further suggests that people tend to assimilate knowledge in different ways, a factor he calls their 'learning style'. He identifies four different preferred styles of learning: active, reflective, pragmatic and theoretical, and he goes on to suggest that educators need to develop ways of transmitting knowledge and different learning strategies in order to accommodate these different learning styles. James and Galbraith (1985) have gone even further, suggesting that there are seven different modalities of learning: print, aural, interactive, visual, haptic, kinaesthetic and olfactory. Students have been shown to benefit when teaching and learning is multi-modal, so that various routes to knowledge uptake are stimulated, thus reinforcing learning.

We have drawn on several aspects of these educational theories in devising the principles exercise, including our insistence that the initial

introduction to spatial modelling, from drawing axial lines and convex spaces, through to calculating integration, was done without using a computer (although in the latter weeks of the exercise, after having done several calculations of integration by hand, the students were instructed on using a computer to generate the numbers and graphics). There were several reasons for this: first, by drawing by hand the students had to slow down their work, and think through the significance of each stage of exercise. Second, it follows from James and Galbraith that using hand-eye coordination may of itself facilitate learning in that the physical and tactile act of putting a ruler down on a piece of tracing paper and drawing a line assists in absorbing the taught knowledge. Finally, though drawing by hand the students had the ability mentally to explore the house as a complete entity. It is a very important aspect of learning in our field that a sense of the overall structure of the configuration is retained but a problem with computers, even with large screen computers, is that there is a tendency to lose sight of the configuration as a whole.

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The Student Learning Experience

The students' learning experience was generally very positive. Subsequent student work demonstrated that they had internalised the learning on the course. This was especially apparent in their ability to understand more complex analytic approaches, for example when they were introduced to urban scale analysis. Likewise, the students' subsequent research projects demonstrated their ability to use analytic evidence to support a well considered research question.

Student feedback on the Principles project confirmed our perception of their experience. Alejandra noted that "the fact that we did by hand most of the calculations and the first drawings was... an excellent way to internalise what we were doing." Whilst Na'amah stated that "The experience from that project was later on very helpful for the [suburban transformations] project." The only criticisms forthcoming were in relation to the workload, with a suggestion that in future we allow the students to switch to computer analysis; and the suggestion that the Minkowski model [viii] can be constructed in a 3D computer model rather than by hand. (Figure 5). Although we agree with the workload suggestions, we feel that building the model by hand has an important pedagogical purpose as explained above.

Figure 5:

Minkowski model of Gehry house, courtesy Alejandra Celedon

Emma's feedback included the conclusion that "I think we all finished the project with a much better understanding and appreciation ofspace syntax research methods and the kind of questions they can be used to address."

From Reflective Practice to Active Research

The advantage of domestic space analysis is that, as houses are a smaller building type, we could ensure that each student took responsibility for one case, which they modelled and analysed from start to finish. Not only did this ensure that all students had the same learning experience but that when they arrived at the comparative analysis, the group collaboration flowed particularly well from the consistent learning experience. Each of the groups worked well to draw a theme together to produce some very interesting sets of research questions and the creative potential of group working became apparent in that the 'whole became greater than the sum of the parts'.

At the start of the exercise we suggested ideas for comparative analyses, such as how space is organised for adults/children, visitor/inhabitants, inside/outside, relation to landscape, visibility/permeability, upstairs/downstairs, intimate/social spaces, front stage/backstage (every day/ceremonial). Likewise, we suggested sample questions for each quartet of houses, so for the 'Modernist Houses', we suggested the students consider the proposition that 'These iconic modernist houses appear so different, yet they were designed almost simultaneously. Do they have anything in common that we can attribute to the modernist philosophy?'

In preparing their presentations, the students had to work as a group to formulate a sequence that began with a well-formed research question and led on to present evidence, findings and conclusions, synchronized and brought together in a narrative. It was interesting to see that there was a variation in approach: in some cases each student presented their 'own' house and they together then concluded on the findings, and in other cases several themes were drawn out to compare across the set of cases. Both approaches worked in different ways and it is evident from subsequent student work that they were able to see for themselves the advantages and disadvantages of each mode of presentation. The students all acquired some basic skills in translating analysis into research.

The Glass Boxes group presented analysis in relation to a question we had suggested about transparency: "How do notions of transparency and visibility relate to the idea of a house as a private dwelling?" They translated this into analysis which focused on the relationship between visibility and permeability, but also considered the relationship between visibility and privacy (Figure 6). They found differing approaches to these relationships across the sample and the students concluded that the range of strategies were a reflection of "contrasting ideologies towards nature and its relationship with architecture" as well as disparate architectural briefs.

The Concrete Cubes group pulled together an interesting presentation comparing their four cases in relation to a question about the relationship between room types, visibility and spatial layout (see Figure 7). Using a range of techniques, including basic isovist analysis, they concluded that the houses they studied are "conventional in that their spatial configuration supports familiar patterns of occupation. However, the experience of being in these houses will be qualitatively different because of the emotional impact of different types of visual field."

Figure 6:

Slide from student presentation on Glass Boxes

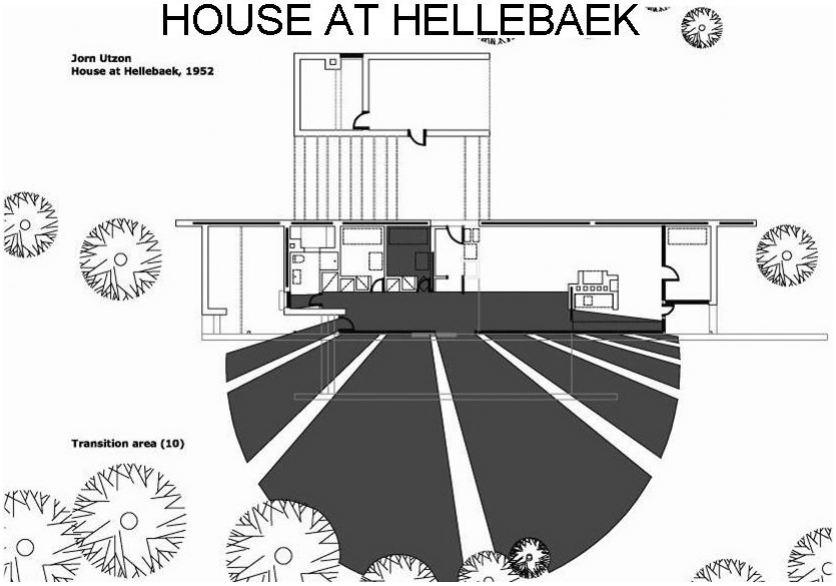

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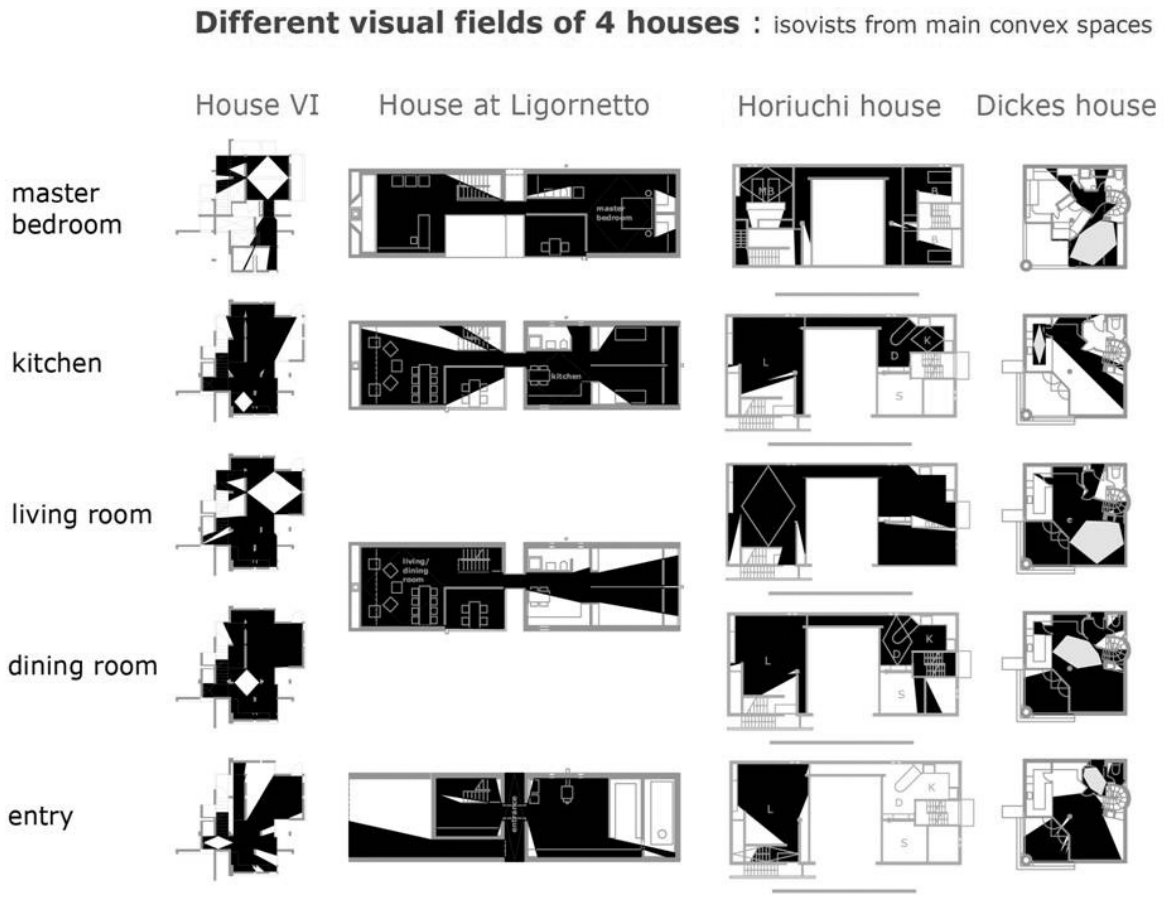
Figure 7:

Slide from student presentation on Concrete Boxes



The 'Breaking out of the Box' group addressed the question we had suggested on the sculptural form of the four buildings: "Does the sculptural form create a novel morphology or is it just an 'appearance' of originality; does it have an impact on configuration and on circulation?" They concluded that the four cases had in common their treatment of the relation of internal transition spaces to the outside – suggesting that "function is enhanced by form" (Figure 8). They proposed an analogy to Cubist artworks, where "artworks, objects are broken up, analyzed, and re-assembled in an abstracted form".

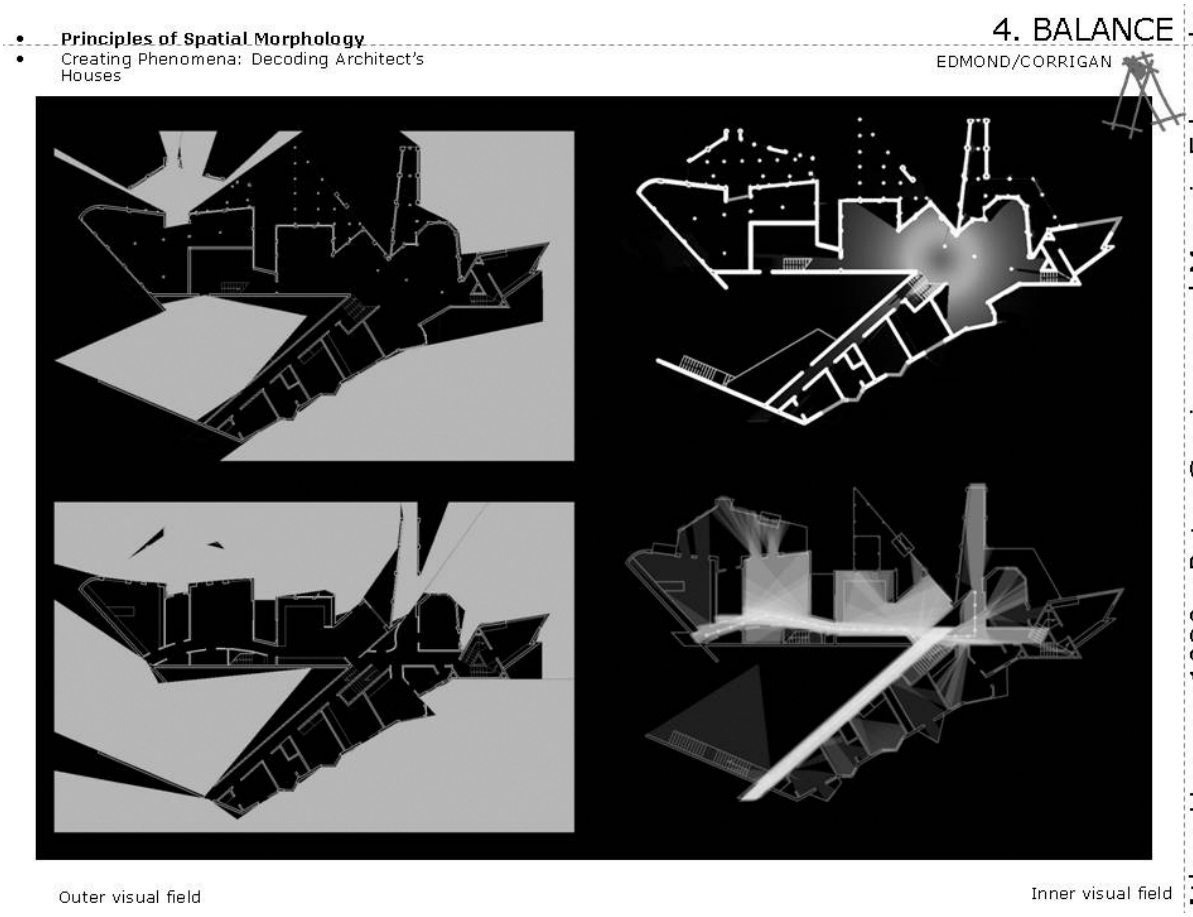


Figure 8:

Slide from student presentation on Breaking Out of the Box

Adapting the Principles Exercise as a Standard Teaching Tool

The exercise described in this paper is only the start of a broad range of teaching and learning experiences provided to students on the MSc Advanced Architectural Studies. Aspects of social and economic change (such as the growth in the numbers of working women, home working, or increasing technological change as illustrated by increased access to the internet) mean that the interpretation and understanding of domestic space in relation to its social and cultural context is likely to be of continuing interest. Informed discussion of these broader social and economic trends is frequently lacking in contemporary architectural training but it is necessary for the broad education of students at the Master's level. Understanding community structures at the neighbourhood scale is another important aspect of the students' learning, which is covered by a second student project (set within the Urban Transformations module), in which the students compare two suburban housing schemes in relation to their morphological form as well as their social, economic and historic context.

Although this exercise forms part of a whole course based around space syntax as a tool for thinking about architectural space, other architectural courses could adapt this mode of teaching to their own needs. We suggest that there is a basic kit of exercises, which if taught in conjunction with some structured reading in the field, can together form a useful learning experience for architectural students on courses where space syntax is not necessarily at the core of the curriculum. We have also shown that although computers are increasingly a necessary part of architectural teaching, it is possible

(and in some cases vital) that students learn through drawing and calculating by hand. The originators of space syntax intended it to be an accessible, democratic way to render the non-discursive (Hillier, 1996) content of architecture amenable to rigorous external scrutiny and public debate, and this will continue to be the case as publications such as Space is the Machine (Hillier, 1996) are provided free, albeit with internet access costs.

Although this exercise was taught in London, from a western cultural perspective, there are other aspects of home life, housing, and neighbourhood that will be relevant to students, wherever they are situated. The exercise is adaptable enough that if it were to be incorporated, for example, into a course on housing in arid regions, additional teaching relevant to the specific environmental context (such as, for example, the way the house acts as a temperature regulator) or cultural content (such as the importance of privacy and the seclusion of women) could be easily incorporated.

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Bridging an Emerging Technology Gap

Progress in any scientific field tends to be uneven, with some institutions taking a leading role in transforming knowledge and others following (Becher, 1989) and this is also the case in respect of developments within space syntax. At one end of the intellectual spectrum, the leading edge research groups are developing ever more powerful theories and graphic interfaces, whilst in other parts of the world researchers have access to little more than the original key text (Hillier and Hanson, 1984), tracing paper and a calculator. This is producing a widening technology gap as the leading research groups accelerate away in several different directions from the corpus of knowledge that lies at the heart of space syntax.

This field-wide phenomenon is to some extent replicated in the learning experience of Masters' students on the AAS course, as they struggle in a very compressed time frame both to acquire the foundation concepts of space syntax and also to grapple with the sophisticated software, computer simulations and spatial models that are being generated by the externally funded research programmes that are driving the search for knowledge within the Bartlett's Space research group. In recent years, the advent of more powerful and faster computers and more sophisticated software has meant that the students expect to have access to computers for their research work from the start of the year. However, we argue that although it is a vital component of the learning experience that students become familiar and comfortable in using computer analysis on the course, the difficulty with introducing computers at the start of the course is that they can become a substitute for asking intelligent questions that can be answered through a configurational analysis of spatial form. In this respect, it is important not to lose touch with the basic tools and techniques that do not require the mediation of the computer.

Moreover, if the techniques and the analysis that are brought to bear on any situation are not grounded in a solid grip on theory, space syntax descriptions and analysis then cease to be 'tools to think with' (Hillier and Hanson, 1997: 01.4). It is all too tempting to jump forward to 'second-order' measures, such as correlations between integration and control, or calculations of isovist integration that are relatively remote from people's everyday experience of buildings and places, without first understanding how the spatial configuration works from the point of view of 'first order' relationships, such as justified graphs, isovists and even the order of integration of the main rooms of a house. These primary representations and measures often capture important properties and qualities of space that directly reflect architectural aspirations and users' experiences. Without the ability to

interpret the results of analysis in relation to theories, there is a risk that the application of computer-based techniques may become an end in itself, rather than a way in which we are able more fully to apprehend the social logic of space.

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i. The AAS course began in 1974. The Principles exercise was reintroduced in the 2006-7 academic year after a break of several years.

ii. An electronic copy of the workbook is available from the authors.

iii. Observing and Representing exercises were:

Task 1: observation task
Task 2: convex break-up
Task 3: convex adjacency graph
Task 4: axial map
Task 5: axial graph
Task 6: justified graphs
Task 7: isovists (see note 7)
Group task 8: Minkowski model (see note 7).

iv. Transforming and Calculating exercises were:

Task 9: enumerating convex spaces and axial lines
Task 10: convex space and axial line connectivity values
Task 11: ratios
Task 12: mean depth calculations
Task 13: RA and RRA
Task 14: integration
Task 15: descriptive statistics, maxima, minima, mean and standard deviation
Task 16: ranking and banding.

v. Information gained on site usually as part of a verification process to check data gathered or produced remotely.

vi. The lecture was based on the plenary session contribution made by Ruth Conroy Dalton at the 4th International Space Syntax Symposium: 'Space syntax and the embodied diagram'. Copy available from the author.

vii. The students were required to draw a series of isovists from the entrance to the 'deepest' (most segregated) room in the house. The definition of the isovist introduced by Benedikt, 1979 is that the entire field of view from a single point can be represented by a planar polygon, usually parallel to the ground plane. The isovists were then used to construct a model from card which built up the set of polygons to represent a 'Minkowski model' of the house. The term' Minkowski model' was coined by Benedikt (1979) and owes its name to the German mathematician, Hermann Minkowski. Minkowski space is the mathematical setting in which Einstein's theory of special relativity is most conveniently formulated. In this setting the three ordinary dimensions of space are combined with a single dimension of time to form a four-dimensional manifold for representing space-time.