

# Characteristics of Architectural Design Tools

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## Summary

The professional roles and functions of architects are linked to the societal context in which they practice. Furthermore, this context has a relationship to the ways in which institutions, groups and individuals are involved in the design and construction of the built environment. This paper illustrates how the roles and functions of architects, other professionals, their clients and the general public have a bearing on the tools and methods used to simulate design projects. Traditionally, sketches, renderings and pattern books were used. Then they were supplemented by axonometric and perspective drawings, written and diagrammatic specifications, photographs and small-scale models. In recent decades mathematical models of diverse kinds, simulation-gaming techniques, including small - and full-scale modelling kits, as well as computer aided design and drafting systems have been used. This paper briefly presents a typology of these tools and an overview of their characteristics. In conclusion, five principles are presented for the application of tools using an integrative approach.

## Résumé

Le rôle et le travail de l'architecte sont liés au contexte de la société dans laquelle il travaille. Ils sont soumis aux relations qu'entretiennent les institutions, les groupes et les individus qui participent aux processus de planification et de construction de l'environnement construit. Cet article illustre comment les rôles et les fonctions de l'architecte, ceux de leurs clients et ceux du public sont en partie liés à des outils et à des méthodes appliquées pour la représentation du projet architectural. Parmi les outils les plus courants on trouve les esquisses, les dessins, les textes, les photographies et les maquettes. Mais récemment des techniques de jeux et simulations avec aujourd'hui aussi le dessin par ordinateur ont été utilisées. L'article présente une typologie des outils, ainsi qu'un survol de leurs caractéristiques. Pour conclure, cinq principes pour l'application des outils dans un processus de planification intégrée sont formulés.

## 1. Introduction

The professional roles and duties of architects are linked to the societal context in which they practice, especially procedures in the building construction industry and customs related to property ownership, land use planning and policy implementation. During the course of history, changes to the ways and the means by which communities, institutions, groups and individuals acquire buildings have had important influences on architectural practice, including the tools and methods commonly used (Alexander, 1964; Heath, 1984). Unfortunately, there are too few social histories or

contemporary studies of architectural practice. This means that there are few indepth accounts of what tools and methods architects use.

This paper is not meant to overcome this limitation. Rather it will present a broad overview of the range of tools that architects have at their disposition in order to represent architectural design projects. However, no reference to computers will be included on the understanding that this subject will be dealt with in another paper. The next section briefly examines reasons for simulating architectural design projects. Then a typology of tools for design practice will be presented. The following section examines the characteristics of two-dimensional architectural representations and it assesses the effectiveness of drawings as a tool for design representations, communication and negotiation. Then other tools and methods including design checklists, guidelines and simulation games are presented. The penultimate section examines the characteristics of small-scale and full-scale models prior to a concluding discussion, which presents five principles for the applications of tools using an integrative approach.

## 2. Why Simulate Architectural Projects?

The practice of simulation as a simplified rendition or representation of a projected setting or event is not new to the physical or behavioural sciences, nor architectural and town and country planning. Simulation has been an integral part of the decision making process of diverse disciplines for many decades. According to Raser (1969) the principal reasons for making simulations are:

1. The economy of experimenting with a facsimile rather than the real object.
2. The observation and measurability of a visible model to test variables and overcome shortcomings.
3. The reproductivity and safety of simulations in order to replicate and modify projects prior to their realization.

The choice of architectural tools and methods ought to be made with respect to these reasons, as well as the nature of the design problem and the inherent characteristics of each type of tool. In general, the purpose of a simulation determines the degree of approximation to reality. In principle, a simulation is not a replica of a real-life situation but a representation of it. From this perspective, the fact that architects and their clients can be (and have been) surprised by their projects once they have been constructed suggests that there may be noncongruence between the perceptions of architectural simulations and built forms. Consequently, it has been recognized that the tools and methods used for representing architectural projects are fundamental components of the design process that can account, at least partly, for the success or failure of projects according to prescribed criteria (Broadbent, 1973; Heath, 1984). Nonetheless, there still is a general lack of concern about identifying and explaining the *unintended consequences* of architectural design projects (Lawrence, 1991). This kind of evaluation should account for the limitations of tools and methods used by architects during the design process.

CLASS OF SIMULATION

	PERCEPTUAL (Experiential, Concrete)	CONCEPTUAL (Abstract)
STATIC	Sketches Photographs Drawings (Perspectives, Axonometrics)	Maps Floor Plans Some Mathematical Models
INFORMATION PROVIDED		
DYNAMIC	"Berkeley Simulator" <sup>3</sup>	On-line Computer Simulation

TABLE 1B  
PARTICIPATORY AND NON-PARTICIPATORY SIMULATION

	PERCEPTUAL	CONCEPTUAL
NON-PARTICIPATORY	"Berkeley Simulator" <sup>3</sup> Public Hearing	On-line Digital Computer Simulation
PARTICIPATORY DYNAMIC	Environmental Modelling	Interactive Graphic Computer Simulation

Fig. 1 A typology of architectural simulations, reproduced by kind permission of David Stea.  
 Une typologie des simulations architecturales, reproduite avec l'aimable autorisation de David Stea.

### 3. Typology of Tools for Architectural Design Practice

In principle, all design representations include simulations of some kind. Generally, the presentation of design projects involves both visual and verbal communication, because a graphic representation or an architectural model serves as a referant around which conversation and negotiation pivots.

In one contribution on this subject, McKechnie (1977, 172) has proposed a typology which he classifies as perceptual (concrete) or conceptual (abstract) and either static or dynamic:

"Building plans, for example, provide much conceptual information - dimensions, angles, abstract shapes; when perceptual information is given, it usually involves construction details that subsequently will be hidden from view in the finished building. Little is provided in a set of blueprints to show the observer how the building will look. In contrast, the scale model

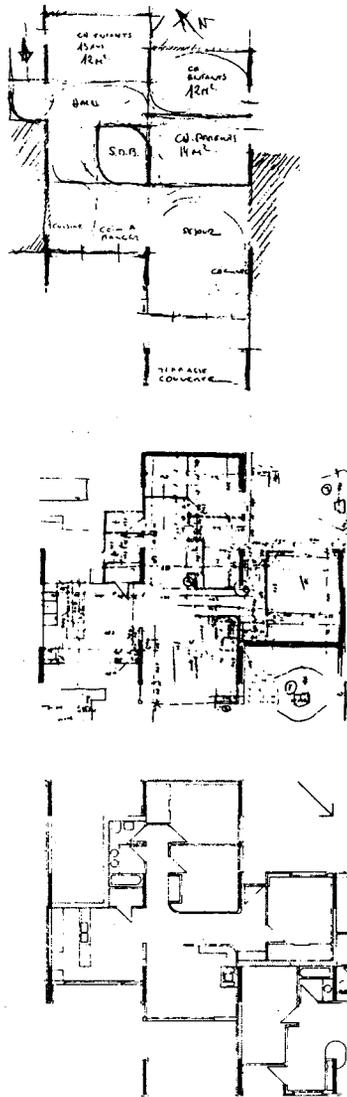


Fig. 2 Three drawings of a dwelling unit before (top), during (middle) and after (bottom) the design process using small- and full-scale models, by kind permission of Groupe Y Architectes.

Trois dessins d'une unité d'habitation avant (en haut), pendant (au milieu) et après (en bas) au cours d'un processus de planification utilisant des modèles à petite et grande échelle. Reproduit avec l'aimable autorisation du Groupe Y Architectes.

at its best provides abundant perceptual information: colors and actual three-dimensional shapes of buildings, textures of vegetation, variations in terrain and ground cover, etc."

Static simulations exist for both conceptual and perceptual modes of architectural representations. On the one hand, sketches and photographs are *static perceptual* simulations, whereas maps, floor plans and some mathematical models are *static conceptual* simulations providing a specific unchanging rendition of an architectural project. On the other hand, small-scale and full-scale models can be used as *dynamic perceptual* tools, while computer aided design and drafting systems can be applied as *dynamic conceptual* simulations. Stea (1988) has provided a synthesis of these types of simulations, as shown in Figure 1A. He then subdivides dynamic simulations into participatory and non-participatory modes in order to introduce environmental modelling, as shown in Figure 1B. This category of simulation uses tools and methods to promote interpersonal dialogue between diverse groups of people, including the public, who are explicitly involved in design decision making. This approach will be discussed later in this paper.

#### 4. 2D Graphic Architectural Representations

Rendered drawings, sketches, words and (sometimes) small-scale models have traditionally been used for the representation and communication of architectural design projects. Drawings have been criticized and defended as an appropriate way to simulate design projects (Cuff, 1980; Lawrence, 1987). Nonetheless, generalizations should be treated with caution, because graphic representations include pattern books, sketches, rendered drawings, construction detailing and cognitive maps. All these kinds of representation are static, two-dimensional simulations generally at a small-scale with respect to a real-life situation. Analysis of these inherent characteristics enables us to identify the strengths and weaknesses of these representations as architectural design tools.

On the positive side, it is noteworthy that drawings not only record human thought, but they can also stimulate it. They are rapidly transcribed and modified. In principle symbolic communication between people is grounded on words and visual representations. From this perspective, a written description of an architectural project, such as a building specification, is quite different from a visual representation of that project. Hence, communication between people involved in the architectural design process can be interpreted in terms of effective image creation and negotiation. Nonetheless, the use of drawings as a means for interpersonal dialogue has been, and probably still is, quite rare in architectural practice (Cuff, 1980). Traditionally, drawings have been used to represent the end product of the design process rather than serve as a tool to document decision making throughout that process. Both these uses of graphic representations should be applied in a complementary way, because the nonuse of drawings as a medium for dialogue is not an inherent shortcoming of this type of simulation.

Nonetheless, on the negative side, two-dimensional graphic simulations are difficult for laypeople to interpret (Lawrence, 1987). The transfer of scale, the two-dimensional representation in contrast to three-dimensional built forms and the difficulties of simulating the *ambience* of architecture suggests that the interpretation of drawings is not simple. This means that they can create a socio-professional distance between

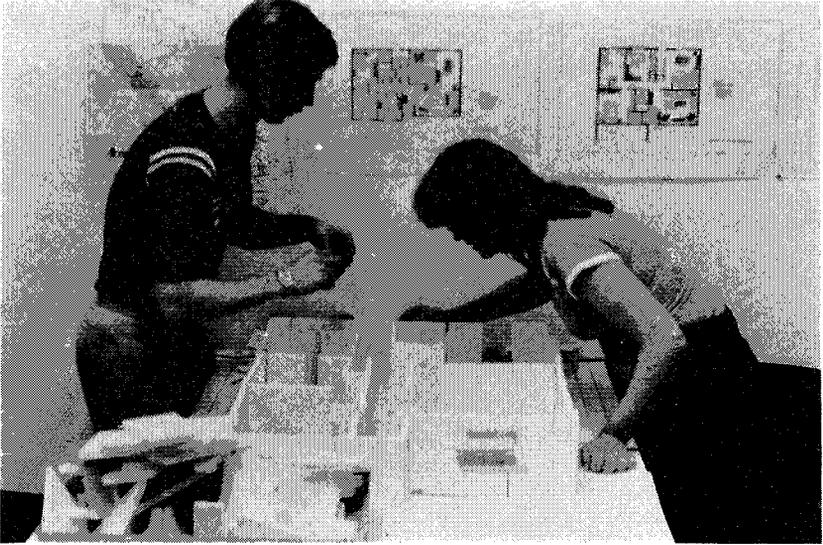


Fig. 3 Views of a small-scale modelling kit during the design process of a dwelling unit, reproduced by kind permission of Bruce Bentz.

Vues d'un outil de modelage à petite échelle utilisé pour planifier une unité d'habitation, reproduit avec l'aimable autorisation de Bruce Bentz.

professional designers and their clients. Although the interpretation of graphic tools and methods for architectural design is not self-evident, the reasons for their longstanding appeal are numerous. Some will now be briefly mentioned.

Perhaps the most important reasons for the predominant use of drawings are related to the interpretation of architectural practice primarily as an artistic endeavour (Collins, 1965; Heath, 1984; MacLeod, 1971). The professional myth of the romantic artist did not originate amongst architects nor is it limited to them. It was invented towards the end of the 18th Century by authors who wanted to promote a type of human character that was explicitly associated with liberal creativity. In particular, the character of the romantic artist was meant to be individualistic, nonconformist and heroic, and it emphasized emotional experience over objective reason as well as inspiration over common sense.

When the role of an architect is equated solely to that of a romantic artist then this interpretation is not only misleading but also counterproductive for the profession because:

1. The romantic artist is an outsider whereas architects should work with clients, other professionals and the public.
2. The romantic artist is an individualist whereas architects always work in teams (Heath, 1984).

Nonetheless, this interpretation of architectural practice continues for other reasons. Graphic representations usually enable architects to control, promote or undervalue specific characteristics of design projects. They become a professional language that enables artistic temperament and subjective judgements to be the basis of decision making, whereas interpersonal dialogue is underplayed or ignored.

## 5. Other Tools and Methods

As building projects of increasing size and complexity have been commissioned during this century, the traditional, integrated unselfconscious approach to architectural design practice has been replaced by a selfconscious approach founded on specialization and segmentation into subjects, stages, functions and roles (Alexander, 1964; Heath, 1984). For example, site development, micro-climatic considerations, building layout, structure and services have increasingly been interpreted as artificial subdivisions of the architectural design process, whereas they ought to be considered from an integrative perspective in order to identify and plan for the interrelations between them. During this development of specialization and segmentation, there has also been a growing professional and bureaucratic distance separating laypeople from most professional groups, including architects, who are meant to offer their services to their clients (Lawrence, 1987). Today, the architect frequently does not deal directly with the users of buildings, and the users may have no personal contact with the client who commissions the building. A range of architectural design tools and methods have been formulated and applied in recent decades partly in response to these developments. These tools include:

1. *Architectural specifications, standards and checklists* usually documented as prescriptive texts that present norms or regulations, sometimes linked to government subsidy schemes (Department of the Environment, 1983).

2. *Design guidelines: Principles, rules or patterns* usually including texts and drawings, such as model floor plans, or Alexander's (1977) *Pattern Language*.
3. *Design Games*, that present formalized processes between two or more parties that seek consensus owing to conflicting choices between options and tradeoffs during the decision making process (Sanoff, 1979).

In general, this range of tools and methods has relied heavily on two-dimensional, graphic representations in conjunction with texts. Furthermore, they focus more on the programming phase of the design process than any of the subsequent phases. However, in recent decades evaluations of buildings in use - some use the misnomer "post-occupancy evaluation" - have grown in volume and kind (Preiser, Rabinowitz and White, 1988). In general, functional and ergonomic criteria are assessed in terms of client and user satisfaction as well as quantifiable criteria, such as cost/benefit analysis using economic values. It is noteworthy that other criteria such as human health and well-being, the use of renewable and nonrenewable resources, and energy flows are frequently ignored (Lawrence, 1991). These limitations suggest that tools for the monitoring and evaluation of buildings in use are too selective. They misrepresent the complexity of the range of impacts of building projects and they do not always consider the contextual conditions of these projects. Consequently, they commonly fail to identify all the *unintended consequences* of specific decisions taken during the design process. These shortcomings should be addressed in the future.

## 6. 3D Architectural Models

A brief history of architectural models should account for the contributions of studies of the scientific management of house planning from the early 1920s in some European countries including Germany and Sweden, as well as experimental studies in building science and technology that tested illumination levels or the layouts of furniture according to ergonomic criteria (Cowan, 1978; Markus *et al.*, 1972). Furthermore, the perceived quality of interior spaces in terms of the surface treatment of walls, floors and ceilings has also been studied using both small-scale and full-scale models (Broadbent, 1973).

These studies were commonly completed in institutions according to experimental or quasi-experimental conditions, abstracted from the affairs of everyday life. This approach has not only been used by architects and building scientists, but also academics and professionals from a number of disciplines including experimental psychology, home economics and medicine. In these fields there generally has been no use of either small- or full-scale models for *in situ* studies with explicit public participation. Rather citizens were usually treated as "reactive subjects" in contrast to "active agents". The shift in the role of citizens from the reactive to the active mode of involvement in architectural research and design practice not only implies a redefinition of the role and duties of architects and other professionals, but also a reexamination of the tools and methods used. From this perspective, the growing application of environmental modelling tools and methods is an encouraging innovation. As Stea (1988) states, and other contributions to this special issue show, this approach uses small- and full-scale models as tools to promote interpersonal dialogue and decision making during the architectural design process.

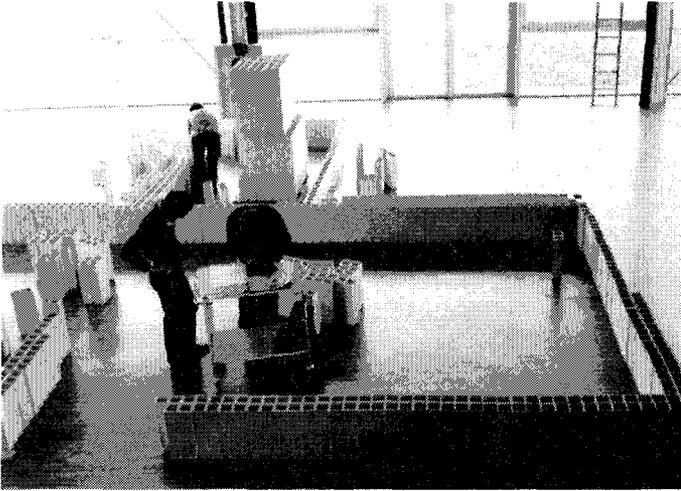


Fig. 4 A design by simulation process using sketches and full-scale models in the Laboratory for Architectural Experimentation at the Swiss Federal Institute of Technology, Lausanne, Switzerland (Photo: R.J. Lawrence).

Une planification par processus de simulation utilisant des croquis et des modèles grandeur nature, Laboration d'expérimentation architecturale, Ecole Polytechnique Fédérale, Lausanne, Suisse (Photo: R.J. Lawrence).



Fig. 5 When using full-scale models during the design process it is possible to use the model, assess it and modify it (Photo: R.J. Lawrence).

L'emploi de modèles grandeur nature permet d'utiliser, d'évaluer et de modifier le modèle en cours de planification (Photo: R.J. Lawrence).

Studies that have used small- and full-scale models in a complementary way show that many non-architects do have difficulty in interpreting small-scale simulations. Moreover, full-scale models overcome many of the limitations related to the interpretation of traditional architectural drawings and models, because they enable people to step inside the simulation, observe it, modify it and reappraise it (Lawrence, 1987). Nonetheless, the limitations of full-scale models should also be borne in mind. Firstly, as these simulation kits are usually accommodated in institutional settings, they cannot account for the site conditions of an architectural project, including sun penetration, views and vegetation. Secondly, although this tool does replicate the correct scale of architectural projects it is ambivalent because the textures, fittings and illumination levels of the model cannot replicate the ambience of the completed architectural project once it has been occupied and used.

Bearing these qualifications in mind, it is suggested that full-scale simulation models are a useful tool for architectural design practice because they serve as catalysts for interpersonal communication and negotiation (Lawrence, 1987). From this perspective the use of these models can be debated in terms of:

1. An effective tool for architectural design practice.
2. An effective tool for architectural education.
3. An effective tool for experimental and applied research.
4. An effective tool for public participation.

The purpose of full-scale models is to represent diverse design possibilities, to give professionals and laypeople a medium to think and communicate with, and to experience, appraise and modify specific characteristics of the project prior to implementation. These models are not meant to serve as facsimiles of projects, but rather as simple renditions of them. Hence, they do not inhibit the elaboration and simulation of alternatives as simply and quickly as possible. From this perspective the role of full-scale models as tools for architectural design is quite different from the common use of architectural drawings and small-scale models of buildings.

## 7. Discussion

The preceding sections of this paper have presented a brief overview of tools and methods available for architectural design practice. However, no discussion of computers has been included. The merits and limitations of diverse tools and methods have been stated and the reader can refer to the bibliographical sources if a more indepth account is required.

This overview of the characteristics of architectural tools shows that there is no all-encompassing tool for architectural design. Each type has its advantages and shortcomings, so that a range of tools and methods can (and should) be used in a complementary way. This use of several tools can aid the representation of projects throughout the design process from the development of the design programme to building construction and evaluation in use. The application of tools and methods for specific projects should be undertaken after the following five interrelated principles have been considered.

1. *Design tools and methods should explicitly account for those conditions and constraints which are context specific*, in contrast to those which can

be generalised from one locality to another. Unfortunately, many design guidelines and patterns do not make this distinction.

2. *Design tools and methods should incorporate constraints or contextual conditions in the design decision-making process.* Both explicit rules and regulations (such as building construction regulations and norms for government subsidies) and implicit codes and conventions (about the layout, meaning and use of spaces) should be understood by all those involved in the design process.
3. *Design tools and methods should not only encourage interpersonal dialogue but also serve as catalysts to seek alternative solutions to the status quo when deemed necessary.* Architectural design should not be restricted to the choice of a limited number of predefined options published in a pattern book or series of design guidelines.
4. *Design tools and methods should encourage the use of two kinds of information.* Firstly, data about personal values and goals as well as their implications on the architectural design project. Secondly, proposals that illustrate how divergent values and goals can be negotiated to provide concrete solutions to specific problems.
5. *Design tools and methods should refer to a long-term or temporal perspective, reflecting the changing uses of built environments over time, as well as their short and long-term impacts.* The criteria used to evaluate design proposals and also buildings in use should be examined critically in order to identify and monitor the unintended consequences of architectural design.

This set of five principles implies that an integrative approach to architectural design practice is necessary. This kind of approach would not only use diverse tools and methods in a complementary way but it would also explicitly include diverse groups of people in society. Consequently, a new socially acceptable approach to architectural practice could be implemented. The stake is significant!

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