Effectiveness of Models

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Introduction

Architects have used many types of models to simulate space, either in their design processes, to show to other people or as final specifications to build them. Although there is some evidence that models can be misleading representations of the real world [1]; many studies have suggested that generally simulations appear to give results similar to those of reality [2]. This exploratory research intends to analyze the variables involved in using the adequate models for specific purposes, mainly for use in architecture. This analysis could offer the possibility to choose more effective models for a required activity. Effectiveness of models refers to the level of performance a model allows to simulate spaces or objects for specific purposes. First, models are analyzed in terms of their use and their types. Then, a number of indicators of effectiveness are considered and finally some models apparently, most used in architecture, are evaluated using those indicators. This evaluation may provide a reference for choosing the adequate model for specific architectural activities.

Use of Models

Models are considered here as physical representations of the real world. In architecture, models can be used as tools in the design process, as presentation tools, as tools for learning or for research [3]. Their use depends on: a.) The objects being simulated; b.) The stage of design a model represents; c.) The view-point allowed by the model; d.) The materials required to build it; e.) The spatial characteristics of the model; f.) The models changeability; g.) The skill of the model maker; h.) The amount of detail required; i.) The number of variables (ventilation, structure, atmosphere) on which the model is required to give information; and j.) The means for the viewer to see the model. The use of models has its limitations, some models allow experimentation with some variables but not with others, some models may take too long to build or may be too expensive. Also models are only surrogates of real space and their verisimilitude cannot be taken for granted [4]. Architects need to work with models in order to visualize their spatial propositions and show them to others. Choosing the correct model requires a knowledge about the types of models available, their performance, their limitations and mainly to have a clear understanding of what the model is intended to achieve.

Types of Models

Models can be categorized in three types:

- Two-dimensional models; drawings, photograph, slides, films, computer graphics;
- Models that yield three-dimensional impressions such as stereoscopic slides, holograms, virtual reality (special computer system);
- Three-dimensional models, such as scaled or full size.

Previous studies [5] have analyzed more then 50 types of models. From these, we analyze in this research: drawings, computer graphics, virtual reality, three-dimensional scaled models and full size models, as according to our opinion, they are basically the most used in architecture at this moment:

1. *Drawings*: are by far the most widely used simulations in architecture and although they are clearly two-dimensional they can express certain three-dimensionality by using techniques such as axonometrics, perspectives, deep sections. They refer mainly to hand made sketches and technical drawings either in pencil, ink, colors or similar materials.
2. *Computer graphics*: have apparently become, in the last few years, the second most used model in architecture either by the student, the architect or the graphic operator (draftsman). The available software allows drawing facilities even to the less experienced. They can be seen directly on the screen of the monitor or in prints. Both computer graphics and virtual reality are interactive presentation tools that can be used to show design alternatives to clients and make changes, almost instantaneously, according to their suggestions.
3. *Virtual reality*: a computer program seen with special equipment that gives the user the sensation of being inside the space and the possibility of manipulating it directly, is probably the most interesting alternative for simulation that has come out in the last two years. Some institutions and schools of design and architecture are using it as a tool for teaching.
4. *Three-dimensional scaled models*: have been used since ancient times to provide means of visualization of spaces; many structures were built by taking measurements directly from detailed models. They allow observers to move around them, so they are also dynamic.Their spatial characteristics offer a sense of depth and atmosphere that seems difficult to obtain with two-dimensional models, but it can also give an unreal impression of the space or object that is being simulated.

5. Three-dimensional full size models: have been used in the last twenty years by some laboratories mainly located in Europe. They allow, according to their size, characteristics and sophistication, the simulation of different types of spaces at real scale and with different levels of realism. They also present a series of limitations related to the module of the wall system used, the type of ceiling, the size, materials, which limits the possibility of exact replications of reality. The use of these models are generally selected by the architects according to their skills or availability and rarely an evaluation is made to determine whether that model was the most appropriate or effective for the intention.

Effectiveness of Models

Effectiveness of models is considered here as *the level of performance of the models* to enable specific intentional activities with the elements of architectural space. Therefore it is *defined in terms of achieving the purpose of the exploration with validity and economy in the use of the resources*. It can be determined by the following indicators : cost, time, changeability, realism, validity, familiarity, attractiveness, projection ability, interlocking ability and ability to select information [1] using specifically defined scales; in most of them, a three level scale defining each indicator in term of low, medium, and high are used as descriptors of each level. These criteria could vary significantly according to the users, the country and other cultural and economical factors.

Cost: three types of costs are considered:

- *Initial cost*: Includes all the items related to building the model;

- *Operational cost*: Includes all the items related to presenting the model for appraisal;

- *Modification cost*: Includes all the items required to simulate changes in the space.

These costs must take in account materials, equipment, software, labor work and electricity. It is obvious that parameters used to calculate factors of use, depreciation or hourly rental of a Laboratory are particular for different countries or institutions. Also labor work and cost of electricity vary even in short periods. To measure this parameters, a survey using architecture students was made, resulting on the following scale:

Scale	Initial Cost	Operational Cost	Modification Cost
low	less than $1	less than $0.20	less than $1
medium	about $5	about $1	about $3
high	more than $100	more than $3	more than $30

Table 1 It can be said that the lower the cost, the higher the effectiveness.

Time: Three types of time are also considered:

- *Building time*: Time required to complete the model;
- *Operational time*: Time required for showing the model;
- *Modification time*: Time required to change part or all of the model.

Scale	Initial Time	Operational Time	Modification Time
low	less than 1/2 h.	less than 1 min.	less than 1/2 h.
medium	about 3 h.	about 10 min.	about 1 h.
high	more than 10 h.	more than 20	more than 3 h.

Table 2 As with costs, the lower the time, the higher the effectiveness.

Changeability: Refers to the capacity of the model to reproduce variations.

Scale	Description
low	means that to make changes the model has to be built new
medium	some of the existing model can be reused to make the changes
high	every part of the model can be reused to make changes

Table 3 Higher changeability means higher effectiveness.

Realism: refers to the amount of details, colors, textures, plants, objects, a model can simulate:

Scale	Description
low	means that the model can not simulate any details
medium	the model can simulate some details
high	the model can simulate all details

Table 4 Higher realism means higher effectiveness.

Validity: is the extent to which findings or reactions utilizing a simulation can be generalized to the real world. It has been called "ecological validity" [6].

Validity is measured using La Scalea's [7] IMIP instrument for psychological impressions: appraisals are analyzed in terms of three factors: dimensional, affective and social. Differences in significance in the three factors are compared in terms of low and high.

Scale	Description
low	means a high difference between the psychological impression perceived using the model and that produced by a real equivalent situation
high	a total correspondence between model and equivalent real situation

Table 5 Higher validity means higher effectiveness.

Familiarity: refers to the previous experience of the user with the type of model (e.g.: A photo may be familiar to a person but not a hologram or virtual reality images).

Scale	Description
low	the user has no previous experience with this model
high	the user has frequent experience with this model

Table 6 High familiarity means high effectiveness.

Attractiveness: refers to the capacity of a model to be enjoyed for its own sake:

Scale	Description
low	impresses poorly for its appearance
high	impresses highly for its appearance

Table 7 Higher attractiveness means higher effectiveness.

Projection ability: Some models cannot show the unreal, that which does not yet exist or is not visible or accessible (e.g.: a foundation, a tension in a beam)

Scale	Description
low	it can not simulate the internal structure of the model
high	it can simulate the internal structures of the model

Table 8 Higher projection abilities means higher effectiveness.

Interlocking ability: refers to the capacity of a model to relate to others. e.g.: a three dimensional model allows draught simulator (wind tunnel).

Scale	Description
low	it cannot be related to other simulation devices
high	it can be related to other simulation devices

Table 9 Higher interlocking abilities means higher effectiveness.

Ability to select information: Is the capability of the model to give information about specific aspects of the object constitution or components. A drawing may give details of how to build a window, a photo cannot.

Scale	Description
low	it offers no possibilities
high	it offers all the possibilities

Table 10 Higher information selection abilities means higher effectiveness.

A Pilot Example of Measurement of Effectiveness of Models

To study the effectiveness of models, we proceeded in the following way: First, four models, which were considered to be of common use in architecture, were analyzed in terms of the ten indicators by a group of selected judges chosen for the purposes of this research between teachers and students of architecture. The four models that were considered of interest to compare were chosen so that they would give similar information. It would have been very interesting to include virtual reality as one of the models, but our Laboratory does not have that tool available yet. A room with simple elements: doors, windows, furniture, was simulated with the four models.

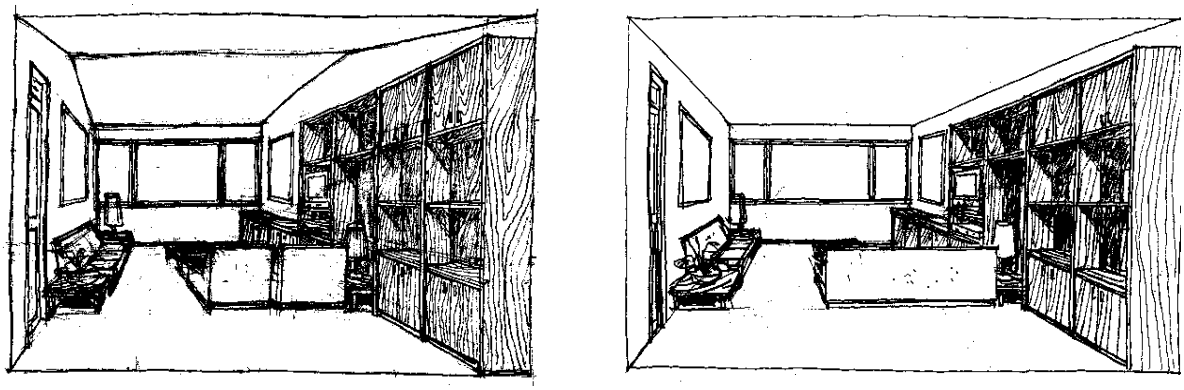

Fig. 1a-b Plans, Sections and a Perspective in pencil sketch of the room.

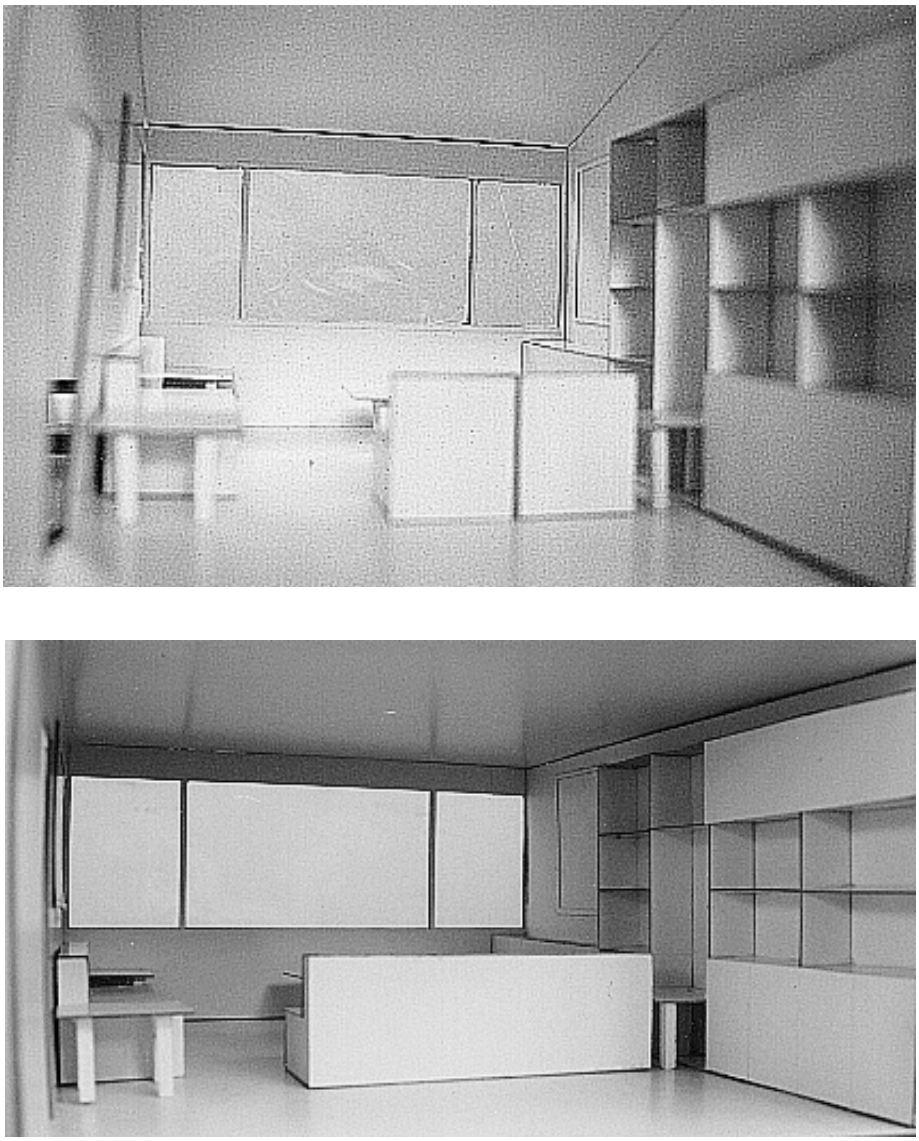

Fig. 2 A walking-through sequence of the room simulated in computer graphics.

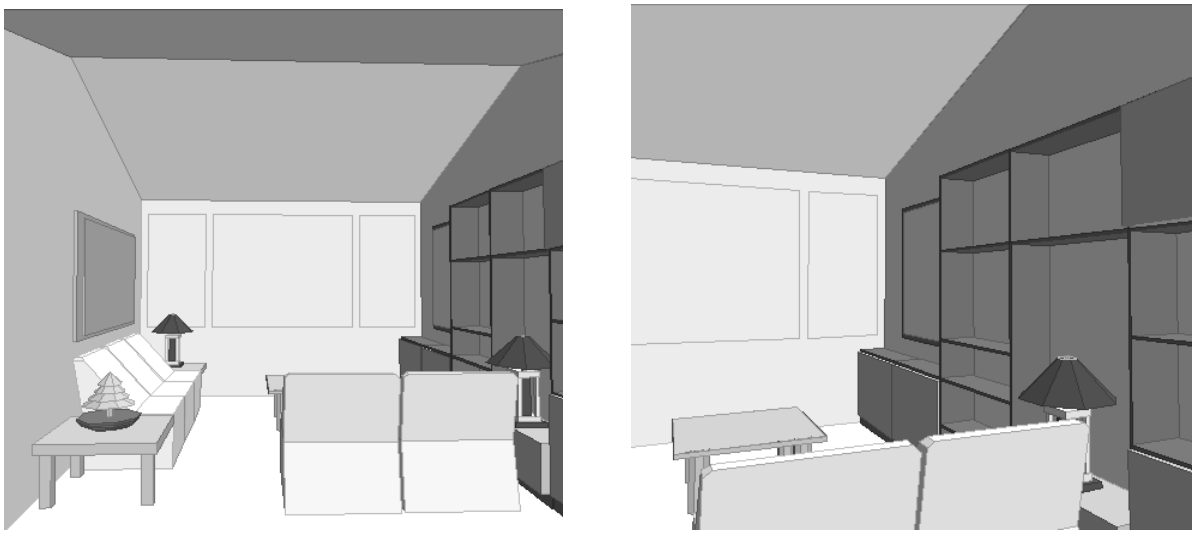

Fig. 3 Three-dimensional changeable scaled cardboard model of the room.

Fig. 4 Full scale simulation of the room.

To evaluate modification time and cost, some of the characteristics of the room were changed: the ceiling, the width of the room, and the size and location of a sofa. A similar sample as that selected as judges for the models choosing, was used to evaluate the previous shown modelations, and its answers can be seen on the following matrix, that shows how the four models are analyzed in terms of the ten indicators.

Indicators of efectiveness	MODELS			
	Pencil Sketch	Computer Graphic	3D Scale model	Full Scale model
Initial Cost (IC)	low	high	medium	high
Operational Cost (OC)	low	low	low	low
Modification Cost (MC)	low	medium	medium	medium
Building Time (BT)	low	medium	high	high
Operational Time (OT)	low	low	low	low
Modification Time (MT)	low	medium	medium	medium
Changeability (CH)	low	high	low	high
Realism (R)	high	high	high	medium
Validity (V)	medium	medium	high	high
Familiarity (F)	medium	medium	high	medium
Atractiveness (A)	medium	medium	high	medium
Projection Ability (PA)	high	high	low	low
Interlocking Ability (IA)	low	medium	high	high
Information Ability (I)	high	high	low	low

Table 11.

In this graphic, as was previously explained, low cost and time means higher effectiveness, on the contrary for the other indicators a low rating means a lower effectiveness. It shows the level of performance of each model, their advantages and limitations. To compare their effectiveness, a second matrix is shown in which the four models are analyzed in terms of their possible performance for specific purposes or activities as: a.) Estate agents showing model of houses to prospective buyers; b.) Participatory design with client: interior decoration; c.) Learning about architectural space; d.) Structural and electrical design; e.) Lecturing about architecture; and f.) Small scale urban design.

	REQUIRED LEVELS OF INDICATORS													Effective
Activities	IC	OC	MC	BT	OT	MT	CH	R	V	F	A	PA	IA	I	Models
Estate agents	M			L				H	H	H	H			M	Comp., 3d Scale
Participatory design		L	M		L	L	H	H	H	H	M				Comp., Full Scale
Learning Arch. Space		L	L		L	L	H	M	H	M	M				Comp., Full Scale
Structural design	M	L	M	M	L	M						H	M	H	Sketch, Comp.
Lecturing on Arch.	M	L	M	M	L	M	H	H	H	H	H				Sketch, Comp.
Urban Design	M	L	M	M	L	M	M	M	M	M	M				Comp., 3D Scale

Table 12.

Conclusions

This is an exploratory research that started in 1979, while doing a Ph.D. in England. Since then, our experience with full-scale model simulation, three dimensional scale models and computers, have given us new insight about the possibilities of their role in teaching and researching on architectural design. We have learned that effectiveness of models is a very complex concept which needs further elaboration. It is necessary to agree on which variables can be generalized and also in the way values are assigned for each indicator. Some models seem to be very effective for many of the activities related to architecture, especially computer graphics, but there are also other models as drawings, photos, three dimensional scaled changeable models, etc., which seem to be also very effective for specific purposes. It is important to continue this analysis in other places, with other groups, in order to have a clearer view of the models that architects will be using in the years to come, and perhaps come out with an effectiveness formula that could make easier the selection of the models for the architectural requirements.

References

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