CHAPTER 15

UTILIZING AN ENVIRONMENTAL SIMULATION LABORATORY IN SWEDEN

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THE DEVELOPMENT OF THE LUND SIMULATOR

Since the early seventies, researchers at the School of Architecture, the Lund Institute of Technology, have developed a procedure which can be used to simulate and evaluate planned physical environments. The emphasis with regard to representation has been on model filming, that is, filming from an eye level which is correct with regard to the scale of the three-dimensional, naturalistic model. Since movement through the model is also represented, the simulated reality is extended to include the time dimension as well, which makes the presentation more dynamic.

One of the first prototypes of this kind of simulating equipment was developed in the sixties at the Landbouwhogeschool in Wageningen, Holland (van Leeuwen and van Ingen 1968). This simulator consisted of a specially manufactured periscope connected to a television camera and fastened in an overhead crane system. It could be moved over a model environment by means of a servo-powered traveling system that made movement possible in the X, Y and Z axes. The movement of the periscope was guided by the filmer from a control desk situated beside the model environment. This early development, called urbanoscope, served as a model to a number of simulation plants, the largest and most advanced probably being the University of California at Berkeley simulator, developed by Appleyard et al. (1973).

After visiting these and other plants, the group in Lund, in order to investigate the advantages of the simulation method, carried out a study of different architectural presentation methods with simplified equipment (Figure 15.1). It was shown that all the conventional presentation methods, like plans, white models, and perspective drawings, gave inferior results concerning prediction of the real environment's actual qualities, in comparison to the model filming method, even if the equipment used at the time was rather primitive.

FIGURE 15.1. The first equipment used in Lund in order to compare various methods of presentation.
This conclusion resulted in an application to the Swedish Council for Building Research for the development of an advanced simulator. Based on practical considerations, the group decided on a 5.5 x 2.5 m overhead suspension system, permanently mounted in the ceiling of a laboratory room, bearing the television camera with the upside-down periscope, or relatoscope, as it is called. A direct steering system controls three servo motors which enable movement in the three axional directions. The model is placed on a table under the suspension system. The height of the relatoscope’s lens over the model is adjustable and corresponds to the model’s scale. A sensor at the bottom of the relatoscope automatically adjusts the eye level to the correct height for eventual level differences in the model (Figure 15.2).

In another room, the picture taken by the television camera is transmitted to a television screen in front of the filmrer/subject, who has a steering wheel and a speed pedal at his or her disposal for direct movement of the relatoscope in any direction. In practice, running the equipment is comparable to driving a car and is very easy. The television circuit can be connected with several television monitors for research officers or observers, and all pictures may be recorded on videotape for later analyses or displayed over public communication systems.

If the equipment is to be used in order to obtain assessments of the simulated environment from test subjects, this can be done directly by means of a “semantic lever” connected to the research officer’s screen where the evaluation is electronically displayed. The test subject’s eye movements may be recorded simultaneously, for example, in connection with a particular sequence of the run through the model. These facilities make the Lund simulator an advanced piece of equipment with many possibilities. It serves to present models of interiors and exteriors in a realistic manner and can be used in both large- and small-model scales, that is, from individual rooms to parts of landscapes. It also enables the detailed

FIGURE 15.2(a) The present simulator.
study of the subjective evaluation and objective eye movement behavior of the viewer. To date, the simulator is only equipped with a black-and-white video system, due to economic reasons. Pictures in color have to be taken on color film. Both 8 and 16 mm film equipment is available. The film camera is mounted on line with the video system, in front of the television camera (Figure 15.3).

THE NEED FOR SYSTEMATIC EVALUATION

The high-quality presentation, however, only constitutes one side of the coin, since there is also the need for qualified judgment. We know from several studies that the intuitive evaluation of the architect is highly subjective (Janssens 1984). For this reason alone, one could wish to establish a method for systematic evaluation based on intersubjective criteria. However, it was the need to assess the experiences of the common user that led the group in Lund to spend considerable effort on the development of various evaluation methods. One of these will be described in some detail.

In 1957, Osgood, Suci, and Tannenbaum had...
shown that it was possible to obtain a relative simple semantic description model by using factor analysis (Osgood et al. 1957). By limiting the area of measurement to the perception of man-made environments, we hoped to obtain dimensions which could be easier to interpret and more meaningful when attempting to evaluate an environment, as well as measurable through a standardized approach. Like Osgood et al., we used seven-step semantic scales, but instead of letting these be defined by opposed pairs, only one descriptive word was, as a rule, used for each scale.

The type of scale used by Osgood et al.:

BAD 0 0 0 0 0 0 0 GOOD

The type of scale used in Lund:

GOOD

slightly 0 0 0 0 0 0 0 very

Using a total of about 200 adjectives on a wide range of environments and subjects of different age, sex, and occupation, it could be shown by means of factor analysis that each of the adjectives related to one or more of the following eight dimensions: pleasantness, complexity, unity, enclosedness, potency, social status, affection, and originality. These eight perceptual qualities are now being used as a means of characterizing architecture and the built environment. The most reliable of the rating scales used have been compiled in a test where pleasantness is measured with eight different scales and the remaining dimensions with four scales each (Küller 1972, 1979).

Thanks to numerous validation studies including comparisons of perceptual and neuropsychological responses, the knowledge about the eight dimensions has increased considerably during the last few years, and the scales have be-
come part of a theory of environmental psychology (Küller 1976, 1980).

In our opinion, semantic analysis has proven to be fruitful, not only in research, but also in application, for example, in simulation studies of various kinds. For example, how does a building that is to replace an older one correspond to it in various perceived qualities? The semantic method is also a good tool when it comes to comparing visually different alternatives for a projected environment. The study on presentation methods discussed later was carried out using this method.

In the Lund simulator, a rating lever, electronically connected with the other equipment, gives the subject the possibility to rate and evaluate the presented environments continuously in any of the eight semantic dimensions. Just like the scales, the lever has seven steps. It may be utilized while the subject is driving around in the model. A continuous evaluation of any sequence may thus be obtained and recorded, together with the picture from the drive, for later analysis.

**COMPARING VARIOUS MODES OF REPRESENTATION**

Planners and designers often feel the need to visualize their projects, not only to themselves and other professionals, but also to the general public. They commonly use representation methods, such as plans, perspective drawings, and three-dimensional white models. Depending on the type of method used, the experience of the environment will shift. The better it corresponds to the future experience of the real environment, the higher the value of the method as a predictive tool.

In order to investigate how different representations can predict the real environment, and how they eventually can be improved, an experimental study was carried out. In this study, two housing areas were depicted that existed in reality. Thus the judgment of reality could be used as a criterion. The following ways of presentation were compared:

1. **Surveys.** Illustrational plan in black and white, scale 1:400
   White schematic model, scale 1:400
   Colored naturalistic model, scale 1:400

2. **Pictures.** Perspective drawings in black and white
   Color slides from eye level in the naturalistic model

3. **Color movie.** Filmed from eye level in the naturalistic model

The two housing areas were about 10 years old and could be considered to have fairly clear physical boundaries. Area 1 consisted of one-family houses, situated in the town of Malmö. Although the different houses were alike and situated in a regular form, their inhabitants had given them rather individualistic looks by using different material in the fences, by planting different types of trees, bushes, and so forth. Area 2 consisted of three-story family houses situated in Lund. The families had no possibility to influence the exterior of the area. The buildings were grouped around a large open place with abundant vegetation. In this green area, there was a play-ground (Figure 15.4).

**FIGURE 15.4.** Retinoscope pictures from models of the two housing areas taken with the first rather primitive equipment.
The areas were judged in reality under two different conditions, nice and bad weather, each by a group consisting of 20 subjects. Comparable groups, each of 20 subjects, judged the two areas as presented by each of the methods mentioned above. The judgments were made with semantic rating scales, and measures were taken on the following five semantic dimensions: pleasantness, enclosedness, complexity, social status and unity.

Comparisons between every method of presentation and judgments in reality were made by analysis of variance. When judged in reality, the two areas received a certain score in each of the five dimensions and could accordingly be related to each other. Suppose, for example, that the one-family area receives a higher score than the three-story area in reality in one of the dimensions. For a method of presentation to be good, it must show the same relationship. If not, the information from this method of presentation is useless. The analysis of variance permitted several comparisons of this kind of the different methods of presentation. This made it possible to rank the methods in the following way as shown in Table 15.1.

It can be seen that the illustrational plan, perspective drawing, and white model contained the most faulty information. This may have been expected but is still quite serious as those methods are the methods most often used in practice. The analysis also showed that pleasantness is the most difficult dimension to predict in a correct manner. This is equally serious, since pleasantness might be considered the most important dimension. It seems clear that the naturalistic model, especially when presented as filmed from eye level, is the best way of presenting a project. It contains the most valuable and least faulty information when one wants to predict the experience of an environment (Acking and Sorte 1972; Acking and Killer 1973).

**THE SIMULATOR IN PRACTICE**

The first requirement of any presentation is that it should be designed to suit the receivers. One of its prime purposes is to serve as a basis for discussion and decisions. Developments in this field have led to a breakdown of the project information so that today it is spread over a number of documents, each concerned with a particular sector of the work. Assembly drawings and quantity specifications are produced quite mechanically, with no overall conception of the planned project.

Because of this emphasis on specialization and the breakdown of information according to sector, there is an increasing need for a separate visual presentation of the project as a whole. In the course of planning and designing an environment, it is important to be able to get a visual perception of it at different stages before the project is finally implemented. Not only do the consumers need a way of visualizing the planned environment, but they would also appreciate the opportunity for gaining an insight into the process by which the environment is being shaped and for having their voices heard on points that concern them.

There is no method that produces our ideas about the environment with complete realism. It is, therefore, necessary to be clear in one’s mind what the image is intended to convey, which methods are the most suitable, and for whom the presentation is intended. For adequate portrayal of a project by means of film or television, the model should incorporate sufficient detail. Three-dimensional models in cardboard or clay with smooth surfaces and facades are unsuitable for this purpose. On the other hand, the model need only be made in stage-set form, depicting just the parts of the planned environment required for the picture.

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**TABLE 15.1. Amount of Faulty Information for Different Representations in Five Semantic Dimensions**

<table>
<thead>
<tr>
<th>Method</th>
<th>Pleasantness</th>
<th>Enclosedness</th>
<th>Complexity</th>
<th>Social status</th>
<th>Beauty</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Illustrational plan</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perspective drawing</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>White schematic model</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Color slides from naturalistic model</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Colored naturalistic model</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Color movie from naturalistic model</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>10</strong></td>
<td><strong>3</strong></td>
<td><strong>4</strong></td>
<td><strong>6</strong></td>
<td><strong>27</strong></td>
<td></td>
</tr>
</tbody>
</table>

*At the time of the study, only these five semantic dimensions had been satisfactorily established.
A simple way of producing stage-set models of facades is to use copies of drawings. Scales of 1:50 and 1:100 are preferable here in order to facilitate the construction of the model. With too small a scale, it will be difficult to obtain enough detail. It should be pointed out that for the finished picture it is only the design and detail of the model, and not its scale, that are of significance. It should be noted, however, that in the preparation of these kinds of models, the amount of detail and stylization should be uniform over the whole model. To prepare realistic facades, it is important to use materials that ensure a correct rendering of textures and reflections. It is also essential to avoid stylized representation of vegetation, for example, by using paper and plastic balls; all shapes must be depicted and structured realistically.

The color intensity that it is intended to apply in reality should be used in the model since this method of presentation affords a direct natural reproduction of the colors employed. Even if the pictures are to be shown in black and white, a naturalistic use of color in the model is preferable since more grey tones give a more correct perception of the simulated environment.

With the relatoscope, it is possible to view models down to a scale of 1:400 at eye level (in relation to the model). An important advantage of the relatoscope is its small diameter (13mm). Its small base area and its tubular form afford easy access in the narrow passages and confined spaces in the model. With the relatoscope, a great depth of field is obtained in the picture. Because of the design of the lens system, however, the optical quality is lower than when, for instance, an inclined mirror is used. Moreover, the relatoscope has a very low light sensitivity, and very good lighting conditions are therefore necessary for filming (Aking et al. 1976).

The simulator has proven to be an excellent aid in environmental studies. It has become a fine pedagogic instrument in architectural education. Students of architecture may use the simulator for presenting their projects even at an early stage of their education. In that case, the technique does not require the exact model craftsmanship that is otherwise used. Instead, models of various types may be put alongside in optional scenes and the alternative project solutions discussed before an audience (Figure 15.5).

The main purpose of the plant, however, was to assist designers, building committees, and the general public in comprehending and foreseeing the impact on the real environment of plans for new constructions or rebuilding. Some of the projects carried out to date will be discussed below. These examples were selected, not because they were the most successful, but because in carrying them through we learned a great deal about environmental simulation.

One project dealt with the representation of a planned highway through a sensitive living area. The authorities had built a model with different solutions and traces. The model was constructed in wood and plastic and painted white. Level differences of the ground surface, as well as trees and houses, were represented in a rather stylized way. The scale of the model was 1:400. Here, also, the different solutions were filmed on black-and-white videotape. The results indicated the obvious difficulties in getting a naturalistic
effect when filming a white snow landscape with circular trees and huge steps in the ground.

Another study tried to investigate the completion of a town square, where different design solutions would be tested. The model was built in a very naturalistic way in wood and cardboard and painted in naturalistic colors on a scale of 1:100. Different parts of the model could be exchanged for different solutions (Figure 15.6). Here, the model was filmed in color with a 16mm film camera mounted in front of the television camera. The results were very realistic, insofar that some local inhabitants thought the sequences with the existing buildings were taken in the real environment. Even so, small differences in lighting conditions caused minor color shifts in the different sequences.

After the Lund simulator had been presented in a number of architectural journals and bulletins, at conferences, and through the press, an investigation was carried out where all Swedish municipalities were asked for their opinion on the use of the simulator in their own environmental planning and design. Even though most of them answered in a positive way and expressed an interest in the equipment’s possibilities as a supplement in decision making, not too many directly announced their willingness to cooperate in the near future. This rather disappointing result indicated several difficulties for the more general use of the simulator.

First, it was felt that the method would be more time demanding thus implying economic sacrifice in a time when local budgets were becoming even tighter. Furthermore, it was thought that certain parties might be able to manipulate the quality of the presentation in a way that best suited their private interests. Finally, the investigation indicated a fear of letting more people participate in the decision process. Since the simulator improves the comprehensiveness for the nonexpert, this would involve the right for common people to be consulted, a development that the authorities did not always seem happy about.

Nevertheless, a number of local housing committees got involved in the use of the simulator and cooperated with the research group, for example, in presenting planned environments to a larger public or for the benefit of their professional staff. For example, one municipality presented the results of an architectural competition in the form of alternative solutions for a planned downtown environment. They built a model where the different solutions could be inserted and then filmed on a scale of 1:100. The model was built in cardboard with drawing copies glued over it, colored in naturalistic colors (Figure 15.7). The different alternatives were filmed on black-and-white videotape and used both as a judging tool and as a presentation method for a larger public. Some other municipalities have cooperated in similar projects.

**RECENT DEVELOPMENTS AND FUTURE PERSPECTIVES**

It has been shown by ourselves and others that simulators are powerful research instruments. The special outfitting of the Lund simulator makes it
potentially useful in basic studies on perception, attention, cognition, and so forth. Since the eye is always looking for points of interest in the environment, behavior dealing with searching for and dealing with environmental information may be studied.

In one basic study, subjects were shown a number of color slides representing different building exteriors, their task being to identify the functions of the structures presented. They were allowed to examine the slides for as long as they wanted. Looking time and eye movements were recorded as well as the time that each person required to identify the building. Afterward, the subjects had to recount the functions of the buildings presented and to explain their interpretations. They also judged the pictures according to a number of semantic variables describing different perceived qualities, for example, pleasantness.

Buildings that were harder to identify not only called for a longer verbal description time, but also for a longer looking and identification time and a more intensive eye movement behavior than did the other buildings. Windows and entries were shown to be the most frequently looked at parts in all the buildings (Figure 15.8). A simple straightforward connection between ease of identification and ratings of pleasantness had been hypothesized. However, no such relationship emerged in this study (Janssens 1984).

A study of the difference between architects and laypeople in eye movement behavior has recently been completed. Among the possible simulator applications of this research is a study of the design and placement of traffic signs, direction finding in urban environments, and the information content of building exteriors.

Another related basic research interest of the Lund group is to study environmental attention
performance. To do this, a simulation technique was developed which uses two slide projectors. With the first projector, a color slide of a genuine built environment remains constant on a screen. Then, with the second projector, it is possible to project/dissolve grey rings into the background slide in a controlled way that corrects for contrast differences between each ring and its environment background by means of a computer. A subject’s attentional performance is measured by two tasks: motoric reaction time to each grey ring and the ability to later recognize the environments he or she has been shown (Watzke and Kuller 1984).

Studies are currently underway in an attempt to find out what qualities in a given environment best explain a person’s attentional performance. If this technique should prove to be useful, a next step would be to apply the same principles using the simulator equipment. With a second television camera, the grey rings could be made to appear on the monitor and subjects asked to respond to those cues as they move through various simulated environments. Such studies would have practical potential for questions about, for instance, traffic and transportation in built environments.

Until now, however, the climate for basic research involving the simulator has been rather cold. One reason for this is the suspicion shown by planners and authorities as indicated above.

Another reason has been the declining interest for perceptual studies during the seventies, since both the research councils and the researchers themselves became more inclined toward applied field studies (Küller 1986). However, at present there is once again a growing awareness of the need for basic research. It is felt that the Lund simulator will play its part in this development.