# MODELLING IN ARCHITECTURE

*physical or virtual?*

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**Abstract.** The use of models is one of the oldest media for creating, communicating and representing ideas throughout the ages. An investigation into the nature and characteristics of two modelling techniques in architectural design, i.e. physical and digital modeling, was conducted in the educational and professional domains in two countries. The aim of this study was to establish: (a) the degree of tangibility in model making as opposed to conventional and computational design approach; and (b) the *iconic* limitation of both types of modelling in design. To this end a survey was carried out among practising architects and students of architecture to establish their preferences and practices with respect to physical and virtual modelling. Some face-to-face interviews were conducted and an online questionnaire was distributed to both the aspiring and established architects. Data gathered through the questionnaire survey, interviews and photographs of the modelling process was analysed to come to tangible conclusions. Hence, this paper presents an insight into the merits and demerits of both the physical and virtual modeling techniques as seen through the eyes of professional and training architects.

**Keywords:** Architectural Modelling, Virtual models, Physical models

## 1. Introduction

Modelling during the design process is one of the most important ways by which any architectural composition can be tangibly perceived. The model,

which may be physical or virtual, is a powerful medium through which a designer can fine-tune his design ideas and also present them. Hence models not only help creation but also creativity in design by virtue of their embodied characteristics.

It is argued that the performance and level of creativity in designing have been affected by the toolbars limitation brought by 3D software and digital technology. This has been a debatable issue since the emergence of the digital technology and virtual reality. The argument is that the direct interaction between the designer and the model is lacking, from the point of view of spatial interactions and tangibility, in digital models projected on the 2D computer screen; whereas, in physical models sculptured objects inhabit the real space of the viewer. Therefore, to enforce such an interaction between the designer and the objects, advanced modelling techniques have been developed in VR (virtual reality) modelling; however, physical models are still the best way of experiencing the spatial characteristics of design tangibly.

The design idea is essentially generated within the human brain three-dimensionally. Until realized, a 'design is essentially a figment of the designer's imagination', although, ideas may be communicated through drawings or specialized design media (Collopy, 2004). As opposed to architectural drawings, which are essentially a two-dimensional interpretation or representation of a design, the architectural model is a powerful design tool that is used not only for representation purposes but is also dedicated to generate multiple design ideas.

Thus, physical models are used to compensate for the lack of clarity found in the two-dimensional representations of design, while digital models may provide a more effective way of visualizing objects with greater accuracy. In fact, the fundamental differences of these two approaches play a significant role in today's architectural design practices. The questions that arise are: "Where do the fundamental differences between the use of physical models and that of the new computer technology lie?"; "What can digital models offer that the physical ones cannot?"; and "if digital models can compensate for the role played by the hand-made models, then why are we still engaged in making hand-made models?

The two types of modelling, digital and physical, have been investigated and compared in various studies in terms of their differences and value-added features in design. It has been found that unlike physical modelling, users of digital models tend to lose a sense of measurement and space. The scale factor is another issue that is detected as problematic through digital modelling. Another drawback of the restricted use of digital models is that the outcomes are often perceived as being 'too perfect, too clean, lacking individual expression and the charm of a handmade' artefact (Breen *et al*., 2003).

Some recent studies identified four major characteristics of physical models that are different from digital models; i.e., "the vision depth effect", "real-time shadow", "quality and quantity effect" and "palpability" (tangibility) (Wu, 2003). Hence, the physical model has some unique characteristics that a digital one does not, that is physically processed, controlled, oriented, and tangibly experienced.

Table 1 presents a comparison between manual, digital and CAM modelling based on the studies of Lim (2006) and Bettum and Schillig (2007)

TABLE 1. Comparison of findings between handmade modelling versus digital & CAM modelling in terms of user & model interactions.

***Handmade modelling versus Digital & CAM modelling***

| Factor | Handmade modelling | Digital modelling | CAM modelling RP & CNC | Notes |
|---|---|---|---|---|
| **Modelling stages** | 2D-3D | 2D-3D | 3D | (RP) directly produce from the 3D file data (layer by layer printing) |
| **Time consumption** | slow | slow | fast | Except when using laser cutting |
| **Accuracy** | less | High | High | |
| **Materials** | More option | More option | Limited | Unrealistic in 3D modelling |
| **Structural analysis** | manually | Computerized | Computerized | Deriving diagrammatic thinking |
| **Constructability** | Direct interaction | No interaction | No interaction | An immediate experience becomes possible |
| **Tangibility** | Occurred from start to end | Not occurred | Only after production | only exist during HM modelling |
| **Spatiality** | Occurred during the whole process | Not occurred | May occurred during assembling | In HM outside-in & inside-out |

The role of architectural models in the design process is indubitable and it would be unusual to find a design project that does not include a model. Be it physical or digital. The aim of our study was to find out the importance and impact of different types of models in both architectural education and practice.

## 2. Method of the Study

In order to obtain detailed information pertinent to our study interviews and questionnaire survey was used. Students and teachers were randomly selected from the schools of architecture at the Middle East Technical University (Ankara, Turkey), University of Benghazi (Benghazi, Libya) and Elmergib University (El-Khoms, Libya). Participants from each university

were interviewed to obtain information on their design approach and modelling abilities; the face to face interviews were based on 18 questions.

An online questionnaire survey, based on 42 questions, was also prepared in English and Arabic, and promoted through social media networks. A random selection of practicing Turkish and Libyan architects from various design offices in Turkey, Libya, and USA was made and the link to the online questionnaire was sent through emails. 65 students of architecture and 22 practicing architects participated in the questionnaire survey. Among them nine students and six architects had already been interviewed and some of their projects' models were photographed (digital and handmade models with different materials).

Students from various nationalities had participated in the survey; 3.4% were from Turkey, 78.2% from Libya, 2.3% from UK, 3.4% from Canada, 8% from USA, 2.3% from Japan, 1.15% from Sudan, and 1.15% from Iran. Among the 87 participants (architects and students) 52 were male and 35 females, of whom 58 were undergraduate students, while the rest were graduate students or professional architects.

Data from the interviews as well as the online questionnaire survey determined the design approach and modeling preferences of the architects and students. In terms of tangibility, the interaction between the designer and the model (physically or virtually) was also investigated. Another crucial issue that concerns most of today's designers is the software limitation and characteristics of materials (physical and virtual models); i.e. which software is preferred; which modelling techniques are used; what modelling material is representative of which real one? To what extent would it be appropriate from the point of view of its structural integrity? Finally, the relationship between the production of models and marketing projects was also investigated from the interviews and questionnaire survey. The questions posed to gather data have not been listed in this paper due to page restriction; however they can be provided if desired.

## 3. Results of Survey and Discussion

This section presents the outcomes of the face-to-face interviews, and the questionnaire survey in both domains; educational and professional. To begin with, 9 undergraduate students in Turkey were interviewed, all of whom were from different academic levels, 1$^{st}$ to 4$^{th}$ year. Almost all the interviewed students stated that their design approach begins with collecting data for the proposed site, diagramming/zoning the collected data, making 2D sketched and sometimes making handmade compositions. Only one student stated that he usually starts with making several physical compositions using as varied materials as possible.

How students are transferring their design ideas from thought to reality was discussed in the interview. It seems that some students still were confined within the conventional design method based on 2D sketching and zoning, despite their preference for the use of digital technology. Other students preferred not get stuck between what they called the "X and Y" coordinates. Other issues such as the sense of scale and modelling materials properties were also discussed during the interviews.

The participants were initially asked why a designer should make a model. They were given multiple choices to answer in addition to the possibility of adding their own comments. The data on their answers is summarized in Figure 1.

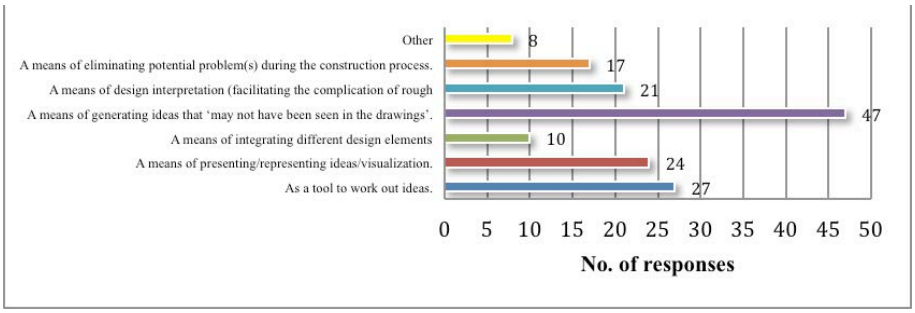


*Figure 1.* Primary purposes for which designers should make their models.

When given a choice between two different modelling techniques, handcrafted and digital modelling (rapid prototyping) the 61% of the 87 participants, preferred to use handmade modelling techniques while 39% chose digital modelling techniques.

Additionally, when participants were asked whether any difficulties in model-making limit their imagination and creativity as designers, 64% answered NO while only 36% answered YES. To find out the reasons behind these two different ratios, participants whose answers marked (YES) were asked to specify their reasons, which were mainly two: the difficulty of modelling complex shapes or free-forms, which sometimes forced the students to abandon or modify their initial design concept, or the lack of skills or tools to make the models.

When asked "what may force a student & designer to change his/her decision- in selecting the applicable material for making their models" Among the 87 participants, 55 chose the availability of materials, 29 chose properties of materials, 24 chose standard dimensions (size & thickness), and 14 the price. When asked about the fastest and easiest medium preferred to present an architectural idea in a hurry, 36 participants indicated their choice to be hand sketches; 29 preferred 3D digital models; 12 use physical models; 9 used 2D CAD drawings; while only one opted for animation.

Having attempted to find out more details of what may be restricting or influencing the design approach of a student or an architect, 67% of the participants say that their design approach is almost influenced by their modelling skills, while 33% did not think so. Accordingly, for having more additional information about the reasons that restricted a students' design approach, it was necessary to investigate whether students had practiced or had some modelling courses to improve their skills. Thus, participants were asked whether they had any courses allocated to model making training in their schools. 38% of the participants stated that they had model-making training in schools, while 62% declared that there were no model-making courses in their schools program. Some mentioned that model making training and practice was usually organized unofficially between the students, i.e. some experienced students offered to train other students to learn some modelling techniques.

To find out how students/architects start their design process, 45% opted for making 2D sketching (on sketch paper) then moving on; 9% preferred starting by 2D sketching using CAD application software then moving on; 13% for 3D sketching using CAAD application software, 30% for those making composition models by hand, and 3% devoted for using both techniques, making 3D composition and 2D sketches together (Figure 2).

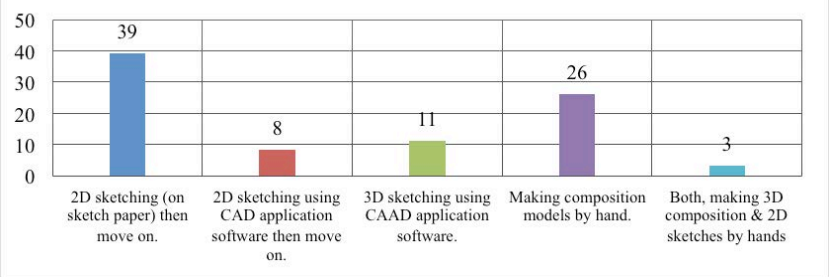


*Figure 2.* Five different design methods preferred by the participants.

Interestingly, although the highest percentage (45%) was given to the use of 2D sketching when starting a design process, most of them (63%) declared that a designer should start working in 3D at the beginning of the design process. Hence, participants were asked, "When do they start modelling or working in 3D?" 55 out of 87 chose at the beginning; 20 in the middle; 10 at the last stage; and 2 said it depended on the size of the project.

Participants were also asked to specify which 3D application they had mastered; choices of the participants are given in Figure 3.

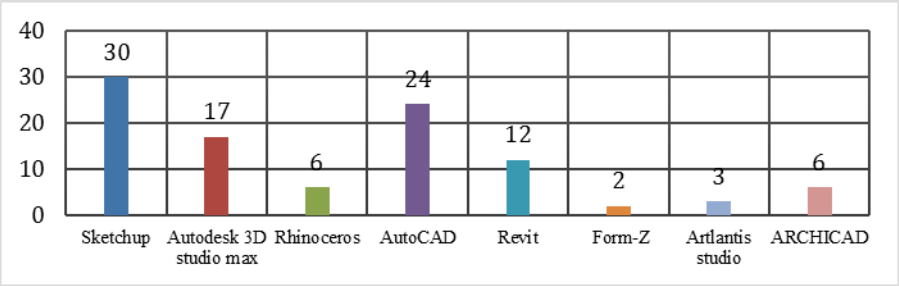


*Figure 3*. The various 3D software used by the participants

General opinions about the usability of models in design are elicited from the survey, 68% stated that models contributed to the design development, while 30% of the participants think that a model may just convey the design intention and 2% for both answers and only one mentioned that models do facilitate the vague of design issues to the client.

Those who used the model in their design analysis (64%) indicated that mostly working with several models helped in the development of generating design ideas and detecting orientation deficiency, i.e. for placing the proper proposal in the location. Others mentioned their use for testing structural behaviour and stability or the analysis of the inefficiency of spaces (thermal behaviour and functionality of materials).

In order to test the structure or for testing the design efficiency some computer software such as SAP, Ecotect and Designbuilder are used for digital models. On the other hand, an example of using the physical model for testing the structural stability and the interactions between the design and the surrounding is given in Figure 4.

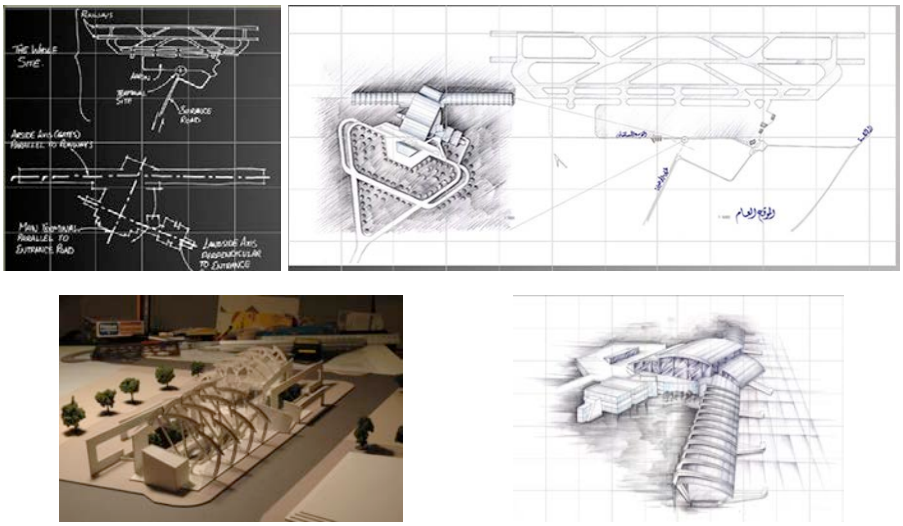

*Figure 4.* Development of an idea through 4 stages of representation by one of the Architect: conceptual sketch; site plans; working model to resolve the structural concept

The questionnaire represented the commonly used scales in 3D modelling among students and architects, and shows whether or not they work with different scales at various modelling stages. Some students mentioned that in schools, scales are usually determined by their instructors. While 38% believe that the use of scale depends on the degree of details for the work required. On the other hand, 46% of the participants stated that they tend to work in different scales when they came up with the main idea of their design, and this is the highest percentage among other selections. 24% usually tend to work in different scale at the detailing stage.

Participants were also requested to state the purpose for which their models were being used. 28 indicated design analysis to be the purpose; 30 indicated final presentation; 26 stated they were used to open up design discussion while only 2 said they were made to test technical/structural issues.

Another impact (of models) that was investigated was the usefulness of models in conveying the design idea when presenting their project model to others or in a discussion. Figure 5 gives data on the 5 possible responses.

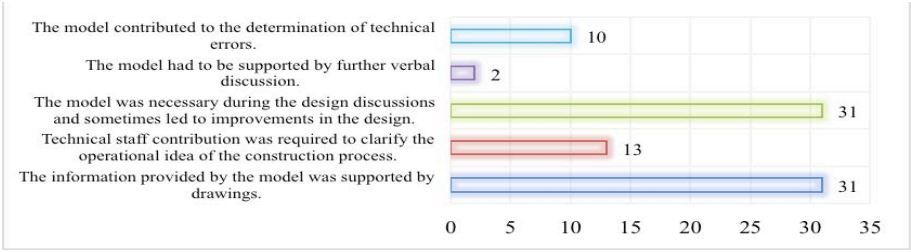


*Figure 5.* Experiences of participants when presenting their project model to others.

To find out the impact of models on the project outcome for both students, and architects, they were questioned separately. The students were asked whether the quality of the project model had an impact on their getting higher grades and 92% of the students agreed. The architects were asked if presenting models to the client had any impact on increasing or decreasing the chance of getting the job? 77% said "Yes" and asserted that not having made a physical model would lose their chance of getting the job, while 23% believed that there was no impact

## 6. CONCLUSION

The face-to-face interviews made with the participants from the three universities included in this study helped to determine the nature of the online questionnaire so as to avoid bias. Accordingly, the informal interviews highlighted some basic concepts of students' design approach, modeling abilities and experiences; that were supported by the data obtained from the online questionnaire.

With respect to the preferred modelling techniques, most students indicated that given a choice they opt for digital modelling rather than physical. They think that making models by hands takes much more time than with computers, especially since the lack experience in handling modelling materials and techniques. They think that they lack these skills because most courses are extensively focused on the use of digital technologies while there are no training courses for manual techniques.

On the other hand, most of the students were not keen to use the hand modeling technique to create and develop their design ideas due to time constraints, limited availability of materials and the lack of experience to cope with making complicated shapes by hand. This drawback reflected the lack and negligence of incorporating model-making courses or training programs in their school. Hence, this led to touch upon how students think and express their design approach for transferring their design ideas from the unknown or invisible state into physical state.

Defining the ideation progress for each student was very complicated to identify. In other words, students were asked to define the transitions of ideas from their minds (unseen concept) until it is visually formulated. Students declared that most of the time what externalized from their minds did not correspond with the nature of their idea that they already had in their minds; they attributed this failure also to the lack of their sketching and modelling abilities and experience. Therefore, some training and practical courses with respect to the modelling techniques may contribute to help students overcome many of obstacles during their design process.

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