Models at Different Scales. A Study on the Inference in the Perception of the Relationship between Space, Body, and Object

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Abstract

The debate of the predominance between drawing and model as design tools is as old as Architecture itself. Up to our days, we cannot deny the centralism of drawings in the process of ideation, configuration, and communication of architecture, but the use of models has never disappeared because both elements result to be complementary.
Is widely known how drawings change in concretion depending on the scale. There is no research if the same thing occurs with models. Basing the study on the works done by students along four courses in an Interior Architecture Degree, this paper delves into the mechanisms of perception behind scale inference in architectural models and discusses their implications for design practice.

Keywords: model, mock-up, scale, perception.

Introduction

The architectural project as an ideation process, although it has incipient examples in the Gothic, emerged definitively during the Renaissance [Muñoz Cosme 2008]. In this period the use of drawings began to spread, but up to this date scale models were almost the exclusive method of architectural conception and expression, and they were considered sufficient for the definition and construction of the building. Even when drawings had started to being massively used, models kept great value as a tool of communication and definition, and the drawing-model debate, as the main means of definition and representation of the project, was far from being overcome [Muñoz Cosme 2008].
When drawing, there is a process of abstraction or concretion that adapts the work to the scale of the physical printing or digital representation. The adaption stands for a better understanding of the results presented and there is a consensus of the line-weight, detail, and quantity of information that an architecture plan must include depending on the scale. But when it comes to models there is no research done in this issue and some questions, already answered for drawings, arise in this realm.
In [Carazo Lefort 2011], The author lists multiple sources in which the history of three-dimensional models has been extensively studied (the same author has published numerous times on this topic). Anyway, he recognizes, talking about research on models, that their objectiveness and playful nature has not facilitated a rigorously treated place in the history of architectural representation [Carazo Lefort 2018].

Fig. 1. The Ribbon. Models at two scales and final mock-up.

What is the proper level of detail that a model must have? At what scale models represent volumes vs spaces? What would be a good scale to represent interior spaces or constructive details?
Beginning with research on the scale of models and the psychological mechanisms of scale perception, the previous questions are the starting point of a study based on the works done by students along five courses in an Interior Architecture Degree. To design a small pavilion, drawings and models are used at three different stages of the design process:

- Preliminary designs, with the use of rough models;
- Final ideation, along with more detailed models;
- Real configuration, finishing the subject building a model, or mock-up, at 1:1 scale.

The use of different techniques, materials, and solutions, according to the scale and degree of development of the design will allow to analyze, compare, and contrast to achieve conclusions on the matter (fig. 1).

Models for thinking

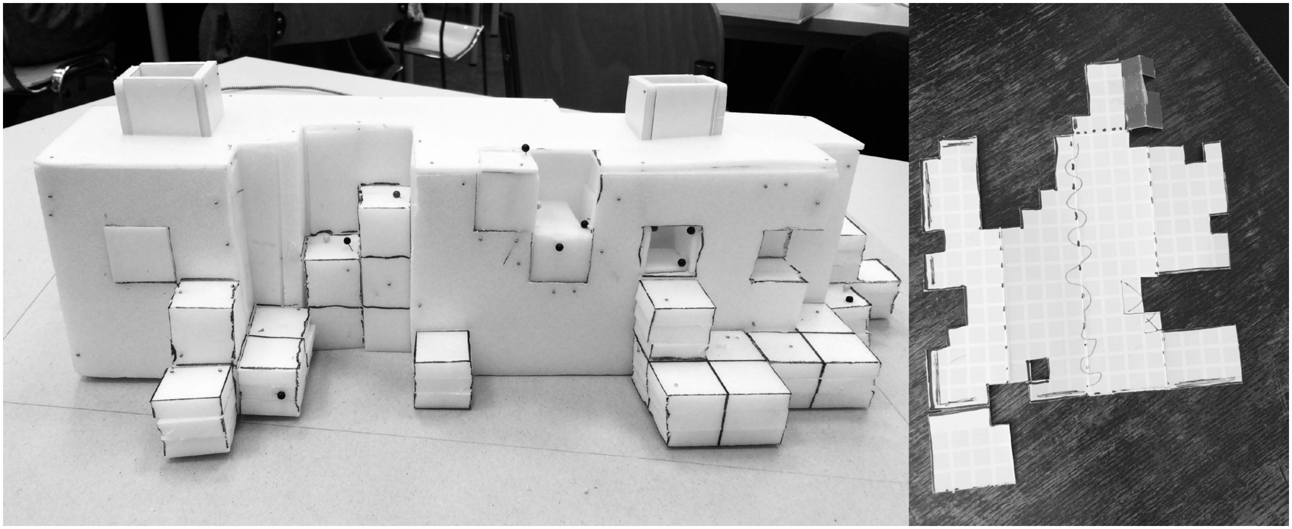
Models play a double role in the architectural process: ideation and communication. An idea already included in Alberti's *De Re Aedificatoria* and clearly exposed by Vincenzo Scamozzi in his treatise *L'Idea dell'Architettura universale*, written in 1615 [Yanguas Álvarez de Toledo 2019]. While these two purposes may seem closely intertwined, they serve distinct roles. Models for thinking are conceptual frameworks that aid architects in conceptualizing, exploring, and refining their design ideas. On the other hand, models for communicating are representations of these ideas, crafted to convey architectural concepts and intentions to clients, stakeholders, and collaborators.
It is known that models developed for thinking may evolve into communication tools as the design progresses, undergoing iterative refinements and enhancements to improve clarity and coherence. But, as the works we are going to study have been developed by students, we will focus exclusively on models for thinking and the role they have in the design process in which they have the condition of a dispositive, a tool, to conceptualize and articulate design ideas.
David Kirsh's work on external representations and cognitive artifacts sheds light on how physical models function as cognitive tools that support architects' problem-solving and decision-making processes [Kirsh 2013]. He states that physical models serve as external scaffolds for architects' thinking, aiding them in organizing their thoughts, visualizing spatial relationships, and testing design hypotheses. Physical models allow architects to externalize and manipulate design ideas in three-dimensional space, facilitating a deeper understanding of form and proportion.
In all this process, scale plays a key role because it impacts not only the physical dimensions of the model but also its visual appearance, tactile qualities, and spatial relationships [Mills 2019].

Scale perception

The perception of scale in architectural models is influenced mainly by two psychological mechanisms, both interrelated. The first one is size constancy, which refers to the perceptual phenomenon wherein individuals maintain a consistent perception of an object's size despite changes in its distance or angle of observation [Gogel 1965]. In architectural models, size constancy allows viewers to infer scale based on familiar objects or spatial relationships within the model. With this comes the other mechanism that is relative size, in which viewers compare the size of elements within the model to each other or to familiar reference points [Palmer 1999]. For instance, the perceived height of doors or windows relative to the overall structure can provide cues about the scale of the entire building. Contextual cues also play a significant role in scale inference by providing visual anchors for comparison [Cornell 1993]. Surrounding buildings, human figures, or other objects within the model serve as contextual indications that help viewers gauge scale accurately.
There are several studies investigating the perception of scale in models that have provided insights that can be used to deepen the knowledge in the area. [Jiang et al. 2019] conducted a study in which participants estimated the size of architectural models under various viewing conditions. The results revealed that viewers relied on both absolute and relative size cues but being the contextual cues the ones that most significantly influence scale perception. Similar research done by [Stamps et al. 2000] explored the effectiveness of different scale

Fig. 2. Vertebrae. Model and final mock-up.

Fig. 3. CUBUS. Rough models in the design process. Design with compact enclosure.



indicators in architectural models. They concluded that human figures were the most reliable scale indicators, but other contextual elements, such as furniture or vegetation, could also aid in scale inference, particularly in the absence of human figures.
These relations stand on the perception of volumes, shapes, and sizes. But, in models, another important factor is materiality and all the sub-factors that depend on it. In the case of an architectural model, its condition as an object, that has necessarily to be concretized having materiality, counterbalances the abstraction that every scalar operation entails, in which the reduction in size implies an inevitable simplification of reality [De la Cova 2016].
Other studies, clarify that materiality has also a wide impact in scale perception. The texture and surface detail of materials influence viewers' perceptions of scale; fine-grained materials may suggest smaller scales, while coarse textures may imply larger scales [Bodmer 2010]. The weight and density affect how viewers interpret the solidity and massiveness of depicted structures. Heavier materials may convey a larger scale, whereas lighter materials may suggest a smaller scale [Ruddle 2007]. Transparency or opacity can influence spatial depth perception making transparent materials enhance the perception of scale by revealing spatial relationships between elements [Jiang et al. 2019]. Regarding reflectivity, materials that reflect light strongly may highlight surface details, enhancing the sense of scale [Dove 2000]. Colour and hue choices in materials can evoke associations with certain scales or environments. Familiar colour palettes may ground the model in a specific context, influencing viewers' perceptions [Stamps et al. 2000]. Familiarity with materials influences viewers' preconceived notions and expectations of scale. Cultural and contextual associations with materials guide viewers' interpretations of scale within architectural models [Holl 1996].
During the preparation for the study, we decided to reduce as much as possible the dispersion of results eliminating some variables by fixing their 'value'. So, aiming materiality not to influence the results, students were asked to only use white materials that had no connection with any real materials when making their different models. Even in the construction of the mock-ups, possible materialities were eliminated using an industrialised system of plasterboards painted in white to formalise the designs.

Defining the students work

The study was developed in a subject of the Interior Architecture Degree of the Berlin International University of Applied Sciences called Interior Construction 1 held during the second semester. Along the four courses that the study lasted, from course 2018-2019 to course 2021-2022, the assignment given to students, even changing the design topic, was basically the same and aimed at the design of a medium-sized pavilion that had to be circumscribed in a rectangle of 2,5 × 3,5 meters, using the drywall construction systems. Its height was free with a maximum of 2,5 meters in the highest point due to the place where the final mock-ups were to be built. There were two deliverable works that had to include mandatory information. On one side a printed booklet including specified drawings at stated scales, sketches, perspectives, and photos of models. On the other side a digital presentation in which the students would present their work with a 5 minute projection including all the mandatory information, always specifying that the presentation should include model pictures. It was also specified that models had to be done in the exploration of the design ideas and then in the presentation of the definitive design, but there was not given a specified scale, letting the students decide on the go.

Fig. 4. Flora. Rough models in the design process. Design in smaller independent part.

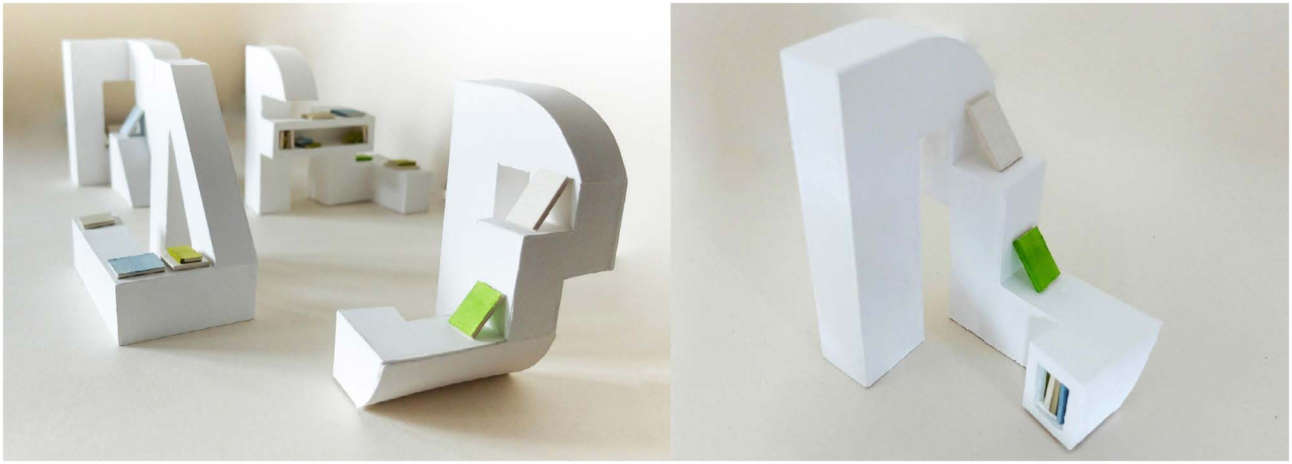
The subject would end with the students helping, together with a professional worker, in the construction of a mock-up of the pavilion at real scale and testing the construction details of the drywall systems studied. In this final phase having to engage in physical manipulation and observation, made them develop a deeper understanding of architectural concepts and processes and offered them the opportunity to experience the spatial qualities of their designs.
This hands-on approach encourages iterative design thinking, cultivating a mindset of inquiry and experimentation. But 1:1 scale prototypes are not generally feasible and this desirable learning by doing technique has to relay on more affordable, in terms of money and time, processes such as the ones that occur in model making.

Models as objects

When starting a design process there is an exploration that often prioritizes overall form and proportions over details [Ching 2014], focusing on developing the fundamental concept and vision for a project. Models created at this stage are mainly used for the exploration of form, massing, and spatial relationships rather than detailed interior layouts [Schwartz 2009].

When in the development of the courses, students were asked to start modelling, we observed that they created, crafted, models that could be easily manipulated with their own hands. Visual analysis of the designs came more from moving the object rather than moving the observer, i.e. the point of view. So, in this situation, it seemed that the key factor was size independently of scale.
Some designs started from a compact enclosure occupying the whole area as preliminary concept and others were made of smaller independent parts that could be linked or added (figs. 3, 4). Therefore, the first ones were generally modelled at smaller scales than the second ones resulting in objects of very similar sizes. Something that fits perfectly at the heart of Campo Baeza's essay *Una idea cabe en la palma de una mano* [Campo Baeza 2014, p. 47]: "That little scale model […] prompts serious reflection on the project itself, the kind of reflection that is characterized by research and at times can prove difficult for non-architects to understand. […] that tiny model is an extremely efficient tool of project research". In his words lies the notion that architectural ideas, despite their grandeur or complexity, can be distilled to their essence and encapsulated within a small physical form, but for that they must be dimensionally encompassable at human hand scale. Understanding this perceptual dynamic at play is essential for comprehending why, at this

Fig. 5. READ. Photos from an 'axonometric' approach.



scales, models are perceived as objects rather than representations of interior spaces [Vrachliotis 2016] knowing that observing this small objects generates 'axonometric' approaches [Carazo 2011], a representation system that can be said to be exclusively used for volumetric drawings and that tends to insist on the interrelation between the parts and on a vision of the building as an artifact [Moneo 2017].
In our case, having to build a pavilion of bigger plan size of 3,5 meters, most of the models measured between 15 and 20 centimetres approximately. Which resulted in scales ranging from 1:23 to 1:17. In the example of a medium-sized pavilion a scale of 1:20 could be appropriate for design thinking, but in houses or buildings it jumps out of the hand scope. Anyway, in some cases it still allows to perceive the designs as objects as Le Corbusier stated in the *Volume 1* of the *Oeuvre Complète*: "*Plusieurs maquettes en plâtre sont exposées à l'échelle de 5 cm pour mètre; c'est une échelle qui permet vraiment de voir ce qu'on fait*" [Boesiger 1999, p. 59].
At this scale models yet allow to 'truly seeing what is being done' because there is the possibility of observing them together, one in front of the other, as if it were a series [De la Cova Morillo Velarde 2016].

Models as spaces

As we have seen smaller-scale models that create small sized objects may focus primarily on volumes and spatial relationships. Some authors say that larger-scale models afford architects the opportunity to incorporate interior details such as furniture layouts, circulation patterns, and spatial organization [Ching 2014]. And this may seem that

Fig. 6. Escherism. Mock-up. Pavilion as an interior space.

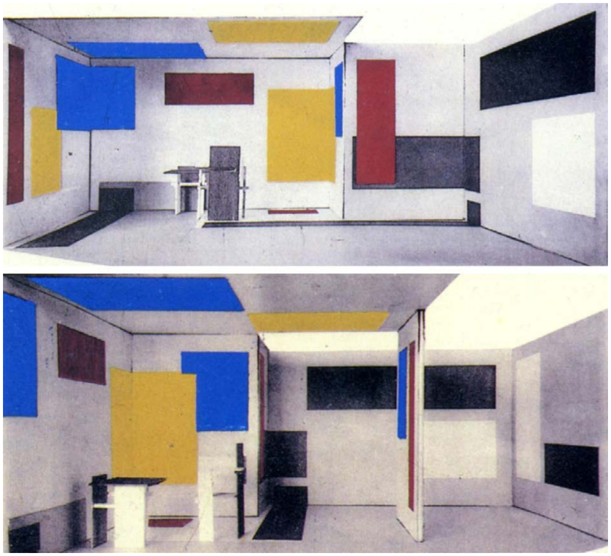


Fig. 7. Original model. Raumlosung. Juryfreie Kunstschau Berlin. 1923. Huszár and Rietveld (Troy 1983).

the specific threshold at which interior representation becomes feasible varies depending on an intended level of detail of the model. But in our study, details, along with materiality, have been consciously erased from the formula and when models start to become bigger, students represent them with photos that get closer to an emulation of real eye-height perspectives but never arriving to a normal person height.
This fact makes us think that the camera size and its field of view impact directly in how the model can be represented and therefore perceived through images. Same thing would happen in real perception, but human face size and possible eye position would be the key factors then. Again, the perception of a model as a representation of spaces that serve as an envelope for human activities depends on size, or relative scale between the model and the viewer, embodied in a camera or in a real person. So, when trying to take a photo of an interior space, the medium eye-height at the scale has to be bigger than the smartphone or the camera dimensions or even larger than the face dimensions in order to allow a realistic position of the point of view.

Actually, in our study, none of the photos is really at an eye-height level, they are taken from higher probably because the camera was too big to place it properly. But when it comes closer to a position that would seem reasonable in the real world, then models are perceived as built realities that surround us.
In his thesis, De la Cova [2016], explains how the Nederland's architects, in the De Stijl exhibition held in 1923 in the Lénce Rosenberg Gallerie expose models that incorporate the idea of space in the three-dimensional model (fig. 7). Through photographs we can deduce that their scale and position admitted placing the eye for observation at a very similar distance that it would be in a real scale construction. He also underlines the contrast that these models had with the plaster massiveness of Le Corbusier models that where compact volumes without holes in the windows or possibility of seeing inside them. A few months later, Le Corbusier's atelier made the first model with an interior –at least known– for Kevin La Roche. The windows were real holes, and to one of the two models done the roof could be removed, in the same way as opening the lid of a box and being able to see inside [De la Cova Morillo Velarde 2016].

Conclusions

Architectural models, need, as happens with drawings, an abstraction that every scalar operation entails and therefore implies an inevitable simplification of reality. They run between multiple scales, it is their condition, but the same can be said about architecture itself. At the end this condition shared by models and real constructions leaves them halfway between object, representation and plastic work [De la Cova 2016].
Following our study, it can be concluded that the key factor that seems to influence the perception of models is size regarding the person that builds or views the model. That is deeply linked to scale, that depending on the real size of the building may vary to adjust to particular dimensions that make the model be perceived differently. On some occasions as an object focusing the attention on its corporeity, in other occasions to the space it embodies.
When the designs were finally built at real scale students said to have those two complementary perceptions, that differentiate so well in models, altogether in the mock-ups. They realized that the process of designing using models had allowed them to better understand the real dimensions that

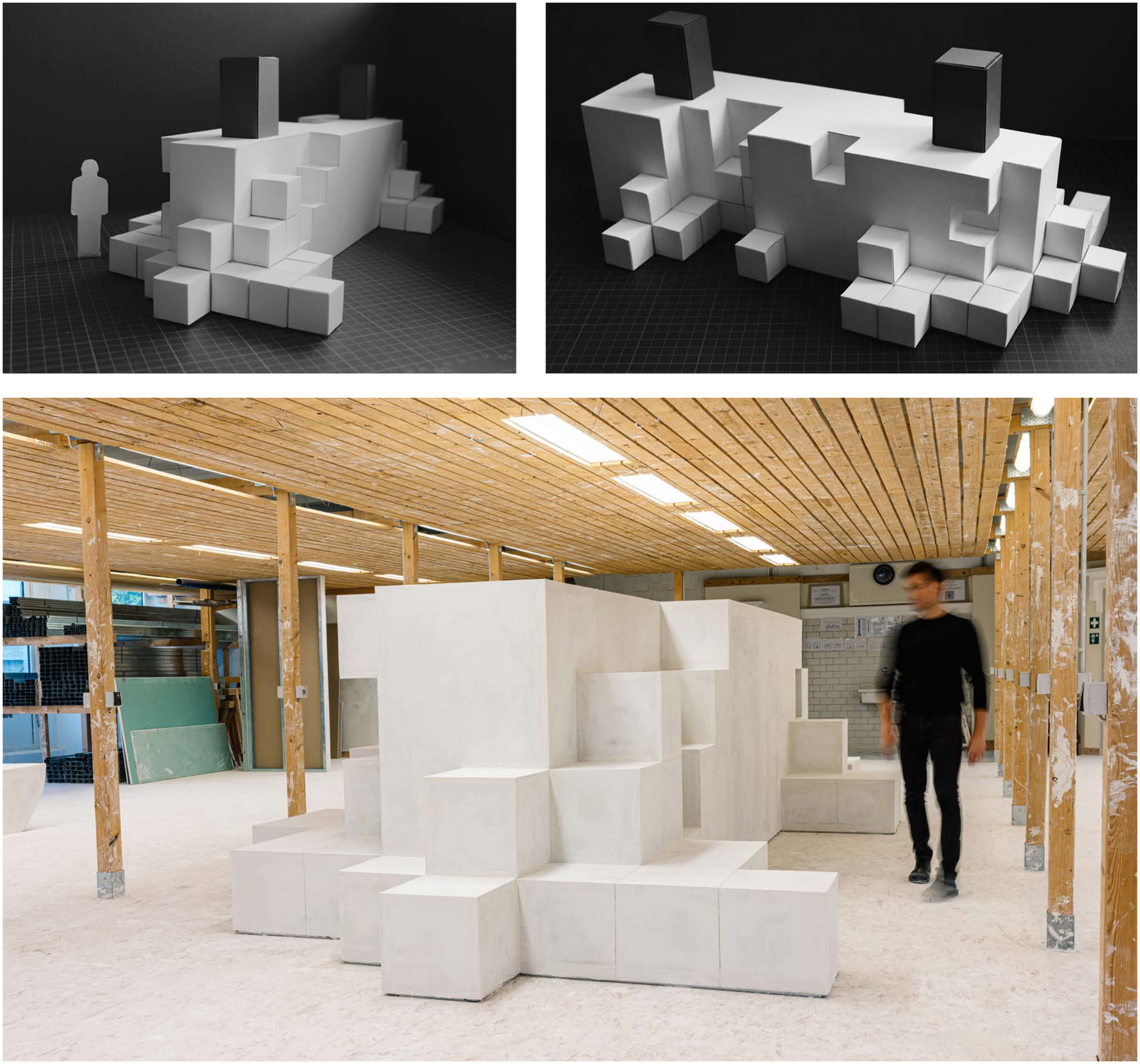
the pavilion was going to have. Some of them had to adjust the measurements as it already happened to Le Corbusier in the design of the Governor's Palace in Chandigarh. He admitted that the scale of the Palace had become excessive, having built on the scale of giants [Le Corbusier 1955], something that became obvious when building the model at scale.

In conclusion, our research paper has highlighted the diverse roles and potentials of architectural models in shaping architectural thinking and practice. From their function as tools for conceptualization and exploration to their embodiment as objects of aesthetic and experiential value, models play a central role in the design process, facilitating creativity.

Fig. 8. Flora. Final design models and mock-up.

Fig. 9. A-MAZE. Final design models and mock-up.

Fig. 10. CUBUS. Final design models and mock-up.



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