Spatial dimensions of bodily experience in architectural modeling: A case study

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Abstract
We argue that the aesthetic dimension of bodily experience is one of the key concepts in the effort towards a deeper understanding of today's crisis in architecture design and is needed to gain insights into the future of digital design environments. Our aim is to explore if there are repetitive gestural patterns among different students during the externalization of design ideas. In order to study the crucial focal points and changes in the way of making in architecture and their relations with the "body" from a historical perspective, we designed a half an hour structured modeling exercise as an experimental study. We repeated the same exercise two times in different institutions with two participants each, all master's level architecture students. In this study we introduce our findings and outcomes in the analysis and comparison of the two modeling exercises based on McNeill's classification of gestures and Lakoff and Johnson's theory of image schema.

Keywords
Bodily experience, Spatial thinking, Gestures in design, Architectural modeling.

1. Introduction

The evolution of technology and human beings are at asymmetric speeds. Because the pace of the evolution, human beings lags beyond the speed of the changes in technology, there is a constant gap between these two processes. Concerning the relation between human beings and technology, the perceptual and the biological limitations of human beings have not been taken into consideration; instead, it has been focused on the speed of technology and its limitations. Within the process of technological progress, the experiential dimensions of the "body" has been neglected. This neglectance occurs at both the literal and the theoretical/conceptual levels. As a result of approaching the human body and the mind, the experience and the thought, the making and the thinking; as two different entities and the reflection of this approach in scientific studies; in the areas of the researches of architectural design, cognitive sciences and the human-computer interaction (HCI) from a methodological and ontological perspective, a certain extent of reductionism occurs. In a broader sense, this reductionist and disembodied approaches have become insufficient to understand the contemporary dynamics and the essence of digital transformation. We argue that the aesthetic dimensions of bodily experience is one of the key concepts in the effort to get a deeper understanding of today's crisis and gain insight about future directions of digital design environments.

Experience is embedded in time, space and body. The two dimensions of experience, space and time are folded with/in body. Time makes the space spatial. In other words, space, time and embodied experience are the complementary dimensions of each other. In the context of architectural design, not only the design representations and their locations in the space but also the bodily dimensions of experience become important. Here the term bodily experience refers to both sensory and cognitive dimensions of experience. However, beyond the real-time sensed experience, there is also a non reductable whole. This nonreductable holistic experience includes the collection of experiences since the early childhood. To mention but not to extend, bodily experience has also cultural, social and biological roots.

Bodily experience acquired through sensory perception by hand gestures has multidimensional/multilayered influence on the thinking process of the designers. The short-term memory of the human beings is limited. The bodily experience acquired through sensory perception causes tacit knowledge. Therefore, body itself becomes an extension of human memory, which spares a tacit knowledge beyond the explicit knowledge. The current digital interfaces and digital design environments do not enhance designer's bodily schemas and multisensory perception adequately. This might be the reason why there is a huge gap between the promised potentials of the digital media and its current inadequate reflections on architectural design curricula.

In the most generalized terms, the main motivation for this study is to investigate how and why the digital environment interfaces used in early stages of architectural design are insufficient in the designers' process of creating abstract and conceptual thinking, and to come across findings that will serve as the basis for digital environment designs in the future. For this purpose, a structured modeling exercise was created that allows the empirical observation of the process which was conducted in a digital environment. The modeling exercise was repeated two times with different participants from different universities. In each experiment two graduate-level students from the field of architecture participated, one of the participants was asked to describe to the other participant four architectural models that they had initially observed. The study was designed in a way to help the participants explain and understand geometrical and spatial relations, and the hand gestures and verbal expressions used in their dialogues were studied. Therefore, the role of the bodily experience, which consists of hand gestures conveying ideas not represented in words, in expressing or creating spatial ideas was examined.

2. The disappearance of bodily experience in digital epoch: a historical perspective

One of the first separations between making and thinking in conceptual level can be traced back the terms that were introduced by Aristotle such as 'technê' and 'epistêmê'. The Greek word "technê" is translated as "crafts or art" (Url-1). The term 'epistêmê' is generally used in terms of knowledge, however the notion of knowledge it represent is different than what we understand from the contemporary version of the word which consists of experimentation (Url-1). "From earliest times until Plato the word techné is linked with the word epistémé. Both words are names for knowing in the widest sense" quotes Heidegger (Heidegger, 1954:6). Heidegger (1954) unfolds the meaning of techné through the word "altheuein" (Heidegger, 1954). Therefore techné involves the affordance, however it "does not yet lie here before us" says Heidegger (Heidegger 1954:5). The activities or the skill of the craftsman bring the potentials and the affordances of the techné into forth (Heidegger 1954:5).

This interpretation of Heidegger is important not only for the mechanical technologies but also the digital technologies. Here, Heidegger recovers the detached / isolated / disembodied assumption of "technology", giving reference to the Aristotelian meanings. Thence, "experience" and "praxis" are needed to bring up the affordances and reveal the "poiésis" of the instruments, in Greek word "aletheia". The disembodied interpretation of techné also caused the detachment between the craftsmen's body and the instrument. As a reflection, both the body and the bodily experience neglected.

In terms of the thresholds for the detachment of way of making and way of thinking relationship between body and architecture, there are important theoretical contributions by Pallasmaa (2005), Carpo (2011) and Picon (2010). Shown in Figure 1 and explained in Figure 2, those detachments have been occurred in verbal, visual, cognitive levels. In architectural discourse and practice, reflections of the separation of body and architecture can be traced. Pallasmaa (2005) indicates the similarity between the "construction in traditional cultures guided by the body" and "a bird shapes its nest by movements of its body" (Pallasmaa, 2005:26). In parallel, Smith (2004) states that imitation of practice and manual works are the way to transmit the knowledge of the artisans (Smith, 2004:7). "Artisanal guilds, their rituals, apprenticeship training, and written techniques constituted the means by which artisanal knowledge was produced" Pamela Smith adds (Smith, 2004:7-8). Therefore as Smith (2004) underlines, this experience of craftsmanship was 'nontextual' and 'nonverbal' (Smith, 2004:8). Some of the basic thresholds in the way of making in architecture is shown in Figure 1 below.

Apart from these detachment in conceptual and theoretical levels in the fourth century BC, we can assume that another detachment emerged in the 1st century BC by "The Ten Books on Architecture" (the original name is "De Architectura Libri Decem") of Vitruvius in terms of verbal description of making in architecture (Pollio, 1914). However, the distance between the body and the way of making in architecture was relatively slight. Still, body and bodily experience were required in order to describe some concepts such as symmetry and proportion between the elements of the body. In the third book of Vitruvius, we see the title of "On Symmetry: In the Temples and in the Human Body" (Pollio, 1914:72).

Another important departure from the body emerges during Renaissance period. "One of the most striking changes that occurred in the Renaissance was the development of visual perspective" Smith points out (Smith, 2004:9). Pallasmaa (2005) indicates Leon Battista Alberti and his perspective as a beginning of a crucial turn
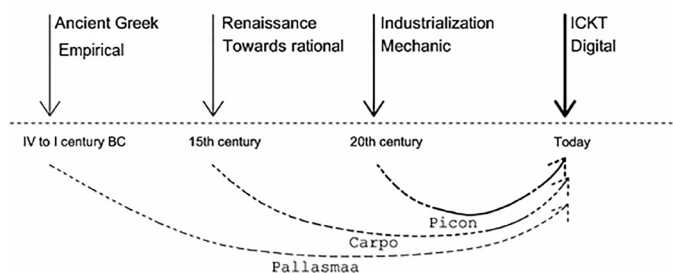

Figure 1. Thresholds for the detachment of way of making and way of thinking.

through the primacy of visual perception, harmony and proportion (Pallasmaa, 2005).

In their 1977 "Body, Memory, and Architecture" book, Bloomer and Moore (1977) trace back the mechanisation of architecture in Louis XVI, 17th century (Boomer and Moore, 1977). Indeed, it is difficult to mention a precise date as a beginning of the paradigm of mechanisation and rationalization. Instead, there had occurred a lot of complex causalities in the constitution of the idea of the disembodiment. Bloomer and Moore (1977) mention the relation between how the body was conceived and how the scientific paradigms evolved at that times:

> The transition from the presence of the body as a 'divine' organising principle in architecture to a more mechanical organisation gained momentum from Galileo's arguments in favour of mathematical measurement and experiment as the criteria for physical truth (Bloomer and Moore, 1977: 15).

Tzonis and Lefaivre (1975) express that: "The manual and the theoretical spheres of architecture were fused into one" (Tzonis and Lefaivre, 1975). Later in the 17th century the separation between theory and practice; thought and making; designer and the laborer had increased. "At the same time the laborer was exemplted from any theoretical activities" write Tzonis and Lefaivre (1975) and they mention the constitution of Royal Academy and formal methods of teaching (Tzonis and Lefaivre, 1975). In their words: "As the divison of labor changed, so did the training of the architect" (Tzonis and Lefaivre, 1975).

During 18th century, the growth of the scientific studies continued, like the specialization in the professions. Instead of embodiment, various methods emerged not only in architecture but also in other fields. The differentiation between the art and the engineering schools can be traced back at
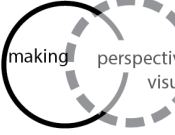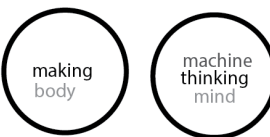
Focal points	Relationship between the way of making in architectural design and "body"	Reflections on practice, theory and discourse of architecture
"Archaic design"		- Overlaps in the way of making and thinking - Written form of knowledge of architecture (Vitrivius, 1st century B.C.) - Craftsmen - apprenticeship relation - Building directly by hands and body - Learning by imitating and doing - "Discourse of divine body and body as building" (Tzonis and Lefaivre,1975)
Renaissance		- Usage of perspective (Alberti) - Fragmentation of sensory experience - Dominance of visual perception - Handcraft manifacture - Craftsmen - apprenticeship relation - Guild type organisation of labour
Industrial revolution		- Separation of "thinking mind" and "making hand"; "theory" and "practice" - Representation of knowledge of making via machines, separate from body and experience - Manufacture - "Discourse of 'the body of the building as a machine' and "'the bodies of the users of the building as machines'"(Tzonis and Lefaivre, 1975).
Digital revolution		- Fragmentation of thinking processes - Representation of knowledge of making via digital media, separate from body and experience - Disappearance of body and body as bits

Figure 2. *Detachment of body from the way of making in architecture.*

this century. Therefore, the distinction between the Cartesian rationalism and relatively holistic experience of art had deepened (Boomer and Moore, 1977). The guild type organization gradually had lost its importance as Tzonis and Lefaivre (1975) states.

Tzonis and Lefaivre (1975) discuss the conceptualization of the architectural design with regards to the body in two periods, the "archaic period" and the "mechanical age" (Tzonis and Lefaivre, 1975). Discourses such as the "building as a body" and the "divine body" of the archaic period are changed into "body as a machine" and "bodies of the users of the building as machines" (Tzonis and Lefaivre, 1975). The industrial revolution also marks the period when the work of the craftsman is fragmented into pieces, whereas before the craftsman had complete control over the decisions made throughout the process, from the beginning to the end (Sennett, 2009).

Taking these points to the 21th century, Picon (2010) states that "certain aspects of digital architecture can only be understood from an expanded historical perspective"(Picon, 2010:9). Similarly, to comprehend the relationship between architectural design and the body, the changes that have occurred in the creative process in architecture as well as the representation of architectural knowledge, needs to be studied. From the period when the craftsman built a brick wall without any prior representation of it, using his body and hands, to the period of modern architecture, which uses computer aided design (CAD), the "body" and the "bodily experience" have gone through many breaking points in the practice, theory and discourse of architecture (Figure 2).

In respect to the relation of the body and the tools, and the conceptualisation of the body, in the digital era the visual representation become much more dominated. Apart from the distinction of the hand and the mind of mechanic era, the fragmentation of the senses emerged. Approaching the senses separately became the common attitude in scientific research. There had been limited number of people who criticized the reductionist growth of the computational approaches. To mention, Pallasmaa, Dreyfus, Lakoff and Johnson's embodiment theory, and Gallagher can be listed. As a key point of the critics of Pallasmaa, suppression of hapticity among the other senses became a problematic for the architects in the digital epoch. Pallasmaa's (2005) defines this detachment and alienation of the technical world as "certain pathology of the senses". Today for architects, visual perception still keeps its dominance in terms of interaction between the design tools and designers.

In brief, there had been a common tendency of dominating the vision in the theories, approaches, and assumptions in 20th century. In the second half of the 20th century this tendency gained acceleration by the impact of development in the information and communication technologies. The disembodied assumptions of knowledge, neglected the aesthetic qualities of experience and the spatial dimensions of the experience. The encounter of the architecture with the digital could not become fruitful enough because of the reductionist and disembodied approaching. The communication and interaction between the architect and the digital media remained insufficient, without utilizing both the potentials of the digital media and the potentials of multisensory experience. The theories of knowledge neglected the tacit dimensions of the experience. Moreover, similar with the previous mechanic era, the specialization brought degregation in the architectural practice. The draftsman of the mechanic era, slightly had been transformed into the render operator of the digital era. This is also because, the technological development did not and still is not provides architect friendly interfaces which support the spatial abilities of the architects.

3. Theories and concepts on bodily experience

Laban (1966) introduces the concept of 'choreutics' to underline the relationship between movement and perception (Laban, 1966). He asserts: "Space is a hidden feature of movement and movement is a visible aspect of space. We must not look at the locality

simply as an empty room. Continuous flux within the locality itself" (Laban, 1966). Petit (2010) highlights the living and dynamic foundations of experience through the etymological investigation of the concept of 'kinesthesia', which covers the sensation mechanism of moving body, and he proposes the idea of blind preverbal, implicit and immanent knowledge of daily experience (Petit, 2010). Sheets-Johnstone (2010) deals with the kinesthesia concept as an awareness of 'qualitatively felt kinetic flow' (Sheets-Johnstone, 2010). Sheets-Johnstone (2010) applies the phenomenological approach to exhibits the felt qualities and patterns of body movement, and after analyzing kinesthetic consciousness, she suggests that 'tension', 'linearity', 'amplitude', and 'projection' are the four primary qualities of body movement (Sheets-Johnstone, 2010).

Lakoff and Johnson investigate how the bodily experience affects the constitution of language, by criticizing dominant thinking about meaning in Western philosophy (Lakoff and Johnson, 1980/2008). They showed that the constitution of abstract concepts is related to bodily experienced spatial orientation concepts (Lakoff and Johnson, 1980/2008). They explain that physical experience and experiencing the world physically and culturally using the body lies at the roots of spatial orientation concepts, such as up / down, in / out, front / back, open / closed or center / periphery. Based on this premise, they state that, although it could show cultural variations, abstract terms such as good / bad or happy / unhappy can be paired with orientation terms such as up/down. They add, for example, "a lot" would suggest a higher ground, or "little" would suggest a lower ground. They also have shown how the future events are "ahead of us", whereas the past is "behind us" (Lakoff and Johnson, 1980/2008). Johnson (2008) states that 'movement' is one of the principal ways by which people learn the meaning of things and acquire an ever-growing sense (Johnson, 2008).

The first source in architecture to refer to the body-image theory is considered to be Bloomer and Moore's "Body, Memory, Architecture" published in 1977:

The body image is informed fundamentally from haptic and orienting experience early in life. Our visual images are developed later on and depend for their meaning on primal experiences that were acquired haptically'" (Bloomer and Moore, 1977: 44; Pallasmaa, 2005:40).

Bloomer and Moore state that the term body-image, or the term imagery in its extended meaning, already include the concepts of body-perception and body-schema (Bloomer and Moore, 1977). They state that "For our purpose we mean to accept the body-image as the complete feeling, or three dimensional Gestalt-sense of form- that an individual carries at any one moment in time - his spatial intentions, values, and his knowledge of a personal, experienced body" (Bloomer and Moore, 1977:37). As for their body-image schemas, they list schemas such as "up/down", "front/back", "right/left" and "here-in-the-center" (Bloomer and Moore, 1977:40).

Gallagher has investigated the difference between the terms body schema and body image using a phenomenological analysis, going all the way back to 1890s to study their etymological and historical roots, and he has shown that these terms have often been used incorrectly in the literature (Gallagher, 2005). Body schemas were described as "sensory-motor capacities that function without the awareness or the necessity of perceptual monitoring" (Galllagher, 2005; Johnson, 2008). Johnson highlights that in addition to this, the body schemas govern the tacit performances that operate below the level of self-refential intentionality, at the preconscious level. (Johnson, 2008). Therefore, "our perception, bodily movement and kinesthetic sensibility" can operate at the preconscious level, in an integrated and spontaneous way (Johnson, 2008). For body-schema, Merleau-Ponty gives the example of reaching over to something using gestures (Merleau-Ponty, 1945/2012:103). Body image, on the other hand, is described as "a person's perception, behavior and belief system about one's own body" (Gallagher, 2005; Johnson, 2008).

3.1. Bodily experience in protocol studies

There are only a few number of studies dealing with the body and bodily experience in architectural design process. Charles observes the role of bodily experience during the design process intuitively without initial assumptions by looking at what designers draw, say, do and gesture (Charles, 2000). Athavankar et al. compare the architectural space image constructed in the mind and the space physically experienced using the 'thinking aloud method' to produce a verbal transcript (Athavankar et al., 2008). Along with this verbal transcript, body and hand gestures are used as data source for analysis (Athavankar et al., 2008). Visser and Maher summarize the state of art on the role of gestures in the design process of an editorial presentation (Visser and Maher, 2011).

Lakoff (1987) and Johnson (1987) have contributed to the embodiment theory with their concept of the "image schema", explained in detail in the next section (Lakoff, 1987; Johnson, 1987). The concept of the image schema was suggested by Lakoff and Johnson in 1987 (Lakoff, 1987; Johnson, 1987). This concept lies at the foundation of the sensory motor experience, which encounters a world that we comprehend and participate in through our executive functions (Johnson, 2008). In other words, according to Johnson, at the basis of all aspects of perception, motor activities and our understanding of spatial terms, lies the image-schematic structure (Johnson, 2008). Therefore recurring patterns and structures (up-down, front-back, near-far, in-out, on-under, etc.) constitute spatial experience and how individuals perceive the word (Johnson, 2008).

Before assuming the image-schema as an abstract, cognitive structure, we need to consider its embodied roots (Johnson, 2008). At this point, a dialectic approach is needed to study the interaction between abstract conceptualization and reasoning processes with concrete bodily experience. Image schemas constitute an important part of our unrepresented world and thoughts, in addition to our sensory-motor experience (Johnson, 2008). Image-schemas function as activation patterns in the topological nervous system maps (Johnson, 2008).

McNeill (1992) classifies gestures under four main groups: (i) iconic, (ii) metaphorical, (iii) deictic and (iv) beats (McNeill, 1992). The term "iconic gesture" was first used by McNeill and Levi in 1982 (McNeill and Levi, 1982). The semantic content of the verbal expression and the iconic gesture is required to have a formal relationship (McNeill, 1985: 354). These iconic gestures are those that express concrete beings and/or actions and convey semantic content that has a formal or pictorial representation (McNeill, 2005). McNeill lists drawing a trajectory through hand gestures, grabbing an object that has width or pointing out to a direction as iconic gestures (McNeill, 2005). The iconic gestures include the "kinetographic" and "pictographic" categories suggested by Ekman and Friesen (1972) (Ekman and Friesen, 1972; McNeill, 1992). Therefore, they can correspond to the portrayal of a bodily movement or a drawing in the air for the content referred to. Metaphoric gestures differ from iconic gestures in expressing semantic content that refers to abstract concepts, memories or thoughts. In McNeill's words, they are the "images of the abstract", and they match the concrete gestures that carry pictorial quality with a content that carries metaphorical content (McNeill, 2005). Deictic gestures refer to those that involve pointing to a certain place in an area using the index finger, but sometimes, the head, nose, eyebrows or feet can accompany the deictic gesture. (McNeill, 2005). Such abstract deictic gestures are considered to be a sub-group of metaphorical gestures (McNeill, 2005). Systematic gestures, also referred to as beat gestures, are gestures that are used while breaking down a verbal narration into pieces.

When verbal content and gestures are compared, the meaning may not match. For situations wherein a gesture corresponds to a word that is expected to come at a prior time or at a later time in a speech, McNeill (2005) uses the term "offset". An 1999 year analysis

conducted specifically for Turkish language which was held at Max Planck Institute in Nijmegen is available in McNeill's book "Gesture and Thought" (McNeill, 2005).

4. Case study: Structured modeling exercise

The case study designed focuses on the following questions:

1. How is the role of hand gestures different than verbal expressions in expressing spatial thoughts in the processes of examining, remembering and describing a physical model, as well as in recreating it in the digital medium?

2. Can we find common and recurrent patterns that people use while explaining a scaled model to another person after having sensorily observed it with hand gestures and touch?

3. Can we deepen our knowledge and understanding of the role of bodily experience in the designing process by making a connection between Lakoff and Johnson's image schemas and McNeill's gesture categories?

4.1. Scope and constraints

For the study, a two-step (Figure 3) experiment was conducted with two graduate level architecture students. The first step consisted of one of the students observing the physical models, and the second step consisted of the other student, who has not seen the models, performing a 3D modeling of these physical models on the computer based on the verbal and gestural directions of the first student. In the first step, four face models (Figure 4) with a scale of 1:1 were used. The models were made with a laser cutter and the participant was given the physical printouts. The methods of production and geometrical designs of the physical models were different from each other. One of them was created by adding parallel cardboards to each other without leaving any space in between. The second model was made of cardboards that crossed each other perpendicularly, leaving spaces in between. The third model was created using non-identical polygonal frames and contained relatively more detailed information, i.e. points of intersection, surface lengths and number of components. The fourth
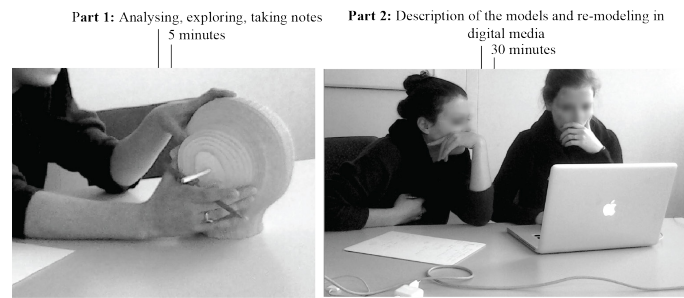

Part 1: Analysing, exploring, taking notes 5 minutes   Part 2: Description of the models and re-modeling in digital media 30 minutes

Figure 3. *Exploring by touching on the left; Digital modeling exercise on the right.*
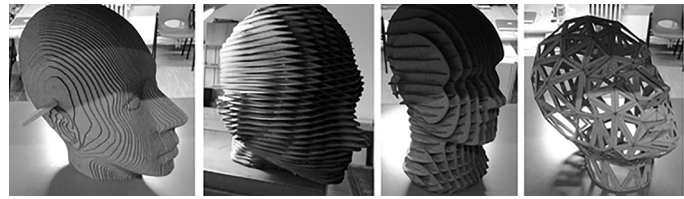

Figure 4. *Physical models which have been used in the modeling exercise.*

model was constructed in a telescopic way, could expand three times its original size and had a dynamic quality (Figure 3).

In this first step, the participant was asked to observe the models for 5 minutes. While doing this, touching, taking notes and sketching was allowed. In the second step, the models were removed and the first participant was asked to describe the physical model's geometrical relationships in words and gestures. None of the participants were informed about the purpose and methods of the study so as to prevent any influence of this information on their gestures. In the second step, a laptop and Rhino software was used as the 3D modeling medium.

This two-step experiment was repeated two times by different participants at different universities. The entire experiments were videotaped. Using the recordings, verbal analyses were conducted on the second steps of the experiments. Experiment 1 lasted 37 minutes and 8 seconds and Experiment 2 lasted 32 minutes and 36 seconds. In this analysis, head and eye movements were ignored and only hand gestures were studied. The sensory feedback obtained through pressing keys on the laptop keyboard or by using the mouse was also ignored. In addition, it should be noted that at the time of the experiments, all the participants had already completed their architectural education.

4.2. Segmentation of the verbal and gestural content

The analyzed video recordings were segmented into pieces, consisting of gestures. In this step, McNeill's (1992) gesture definitions, which consist of four categories: iconic, metaphorical, deictic and beat, were used. Experiment-1 provided 120 pieces and Experiment-2 provided 103 pieces.

The participants were observed to be focusing on the computer screen or conveying the model's geometrical information by sketching or engaging in a face-to-face dialogue, in no particular order. Based on these different types of engagement, three categories were determined where gestures were executed: computer screen, paper and none. If the computer screen became

the main focus of the communication between two participants, we tagged the medium of the gesture as "computer screen". In the case of touching to the computer screen, and/or the case of pointing the screen by the hand were evaluated under this category. If one of the participants make sketching by using a pen or a pencil; or if one of the participants points out a detail on the sketching paper whether touching or not; we evaluated these situations under the category of "paper". A third item, "none" refers to the usage of hand gestures in the air without a supporting media.

4.3. Evaluation and comparison of the two modeling exercises

In this part, the distribution of the gestures, the spatial quality of them which we call "augmented gestures" and gesture-medium relationship are examined and discussed. The distribution of these gestures in the verbal analysis can be seen in Table 1.

Seven of the deictic gestures in Experiment-1, and 6 of the deictic gestures in Experiment-2 carried iconic and spatial qualities. These "iconic/deictic" gestures did not only point to the geometric object as a singular object in the environment, but also gave information on its direction, angle, its sphere-like quality and its representation of an area as a circle. These "iconic/deictic" gestures that contain spatial qualities are evaluated under the category of deictic gestures (Figure 6, Deictic gestures).

The following spatial qualities are seen both in Experiment 1 and Experiment 2: verticality, horizontality, sequentiality, expansion of the piece of the model, direction, orientation, angle, spatial relations, circular movement, connections, frames, simulation of the shape in 2D, simulation of the geometry in 3D. As it is seen in Figure 6, all the iconic gestures are assumed to convey spatial qualities. More than half of the metaphoric gestures convey spatial qualities. For example, where the verbal content is "column like trees", the participant simulated the growth of the brunches of a tree by two hands in the air. This metaphoric gesture has motion quality and it also shows the di-

Table 1. *Distribution of the gestures in two modeling exercise.*

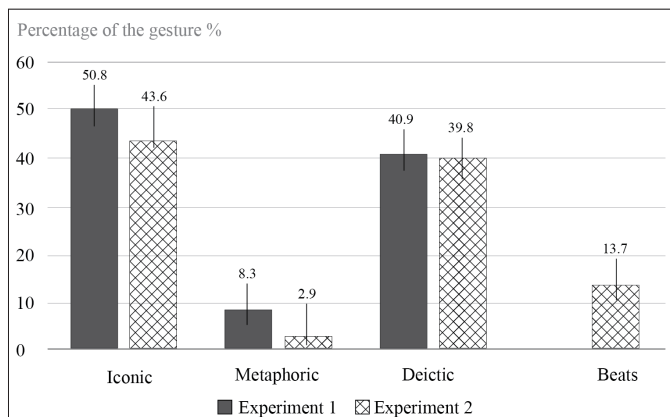|	Iconic	Metaphoric	Deictic	Beats
Experiment 1	61	10	49	0
Experiment 2	45	3	41	14

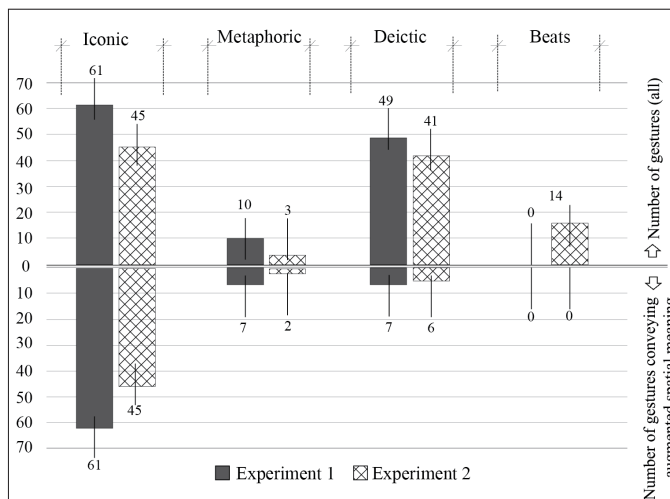**Figure 5.** *Distribution of the gestures as a percentage in two modeling exercises.*

Figure 6. *Occurrence of spatial qualities with/in the gestures.*

rection of the growth. In general, deictic gestures are expected to point some point in the space. Therefore at least the indicated point has a direction. However, in Figure 7 we disregarded this one dimensional information and counted the deictic gestures as not conveying spatial quality.

The expression of the physical model through hand gestures in the space above the table plane ("none") and on the sketches made on paper ("paper") involved more iconic gestures compared to those used for the computer screen (Figure 7). When the computer screen was the main focus of the participants, deictic gestures were used significantly more often (Figure 7). The execution of the deictic gestures involved the index finger touching the computer screen to point to the digital model as a whole or in part. In the 33 deictic gestures where the model was pointed to on the computer screen, 4 of them carried an iconic quality as well. For example, the sentence "Let's carry this from here to here" was accompanied by pointing to a starting point, the direction towards which the action was to take place, as well as the destination point on the computer screen.

When verbal and gestural content is compared, shifting the meaning forward or backward has significance in terms of Lakoff (2008) and Johnson's (2008) source-path-goal schema. McNeill (2005) calls these shifts as "offset (McNeill, 2005). While explaining the physical model using a sketch or using hand gestures while sitting face-to-face, iconic gestures were used in "forward" and "backward" offsetting. While the focus was on the computer, the offsets were encountered less often and in the form of deictic gestures (Figure 7). Considering the relationship between iconic gestures and the image schemas (Figure 6 and Figure 7), iconic hand gestures can be said to offer stronger support of the source-path-goal schema during communication in a physical environment.

Both in the two exercise it seen that, participants might utilize different gestures for the same verbal data. For example, once they expressed the geometry of the model in detail by using iconic gestures, for the second
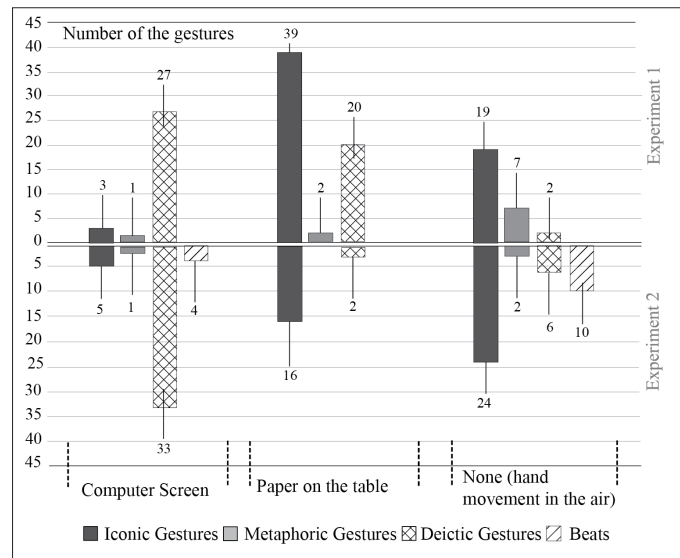

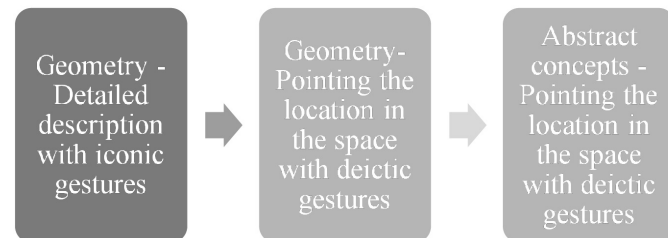*Figure 7. Comparison of two modeling exercises in terms of the type of medium.*

Figure 8. Iterations and transitions.

or third time they tend to use deictic gestures and only point the location in the space. This location can be both a detail on the drawing/sketch or an arbitrary space in the air. This situation is shown in Figure 8.

5. Concluding remarks

In a broader sense this study sought to answer the question, "What is?". This might be the reason why there is a huge gap between the promised potentials of the digital media and its current inadequate reflections on architectural design curricula. Despite the rapid progress in CAD and CAM technologies in the last two decades, today conventional methodologies such as sketching and model making are still crucial in architecture education. This research should be considered as a preliminary step in understanding why and how the digital interfaces are insufficient in designers' creation of abstract and conceptual thinking in the early stages of architectural design. We argue that the aesthetic dimensions of bodily experience is one of the key concepts in the

effort to get a deeper understanding of today's crisis and gain insight about future directions of digital design environments.

In this study, where a modelling application was used, the role of bodily experience, which was complemented by hand gestures and conveyed information that was not verbally expressed, was investigated in the process of expression and creation of spatial thoughts. In the modelling process in a digital environment, the repetitions, patterns and relations in the hand gestures of a participant asked to describe a physical model, were observed. Iconic gestures complement the verbal dialogue when the relationship between the components of a physical model and the spatial information is being conveyed. In some situations, the gestures, particularly the iconic gestures, were observed to support the source-path-goal schema and the movement schema simultaneously. For instance, we have encountered situations where the kinetic qualities of the physical model were expressed only in gestures, without any verbal expression. The hand gestures do not only convey geometrical qualities of the model, but also the becoming process of an action. In addition, it is sometimes possible to use the same verb for two consecutive sentences and to connect the two sentences to each other through gestures.

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