This paper proposes a framework for integrating physical and digital design medium addressing a sensorial aspect of design thinking. The theoretical framework, the process and the results of two consecutive exercises taught as a preliminary project of an interior design studio are introduced and discussed. The approach aims to determine intuitive modes of communication between students and digital environments.

**Keywords:** digital design, design theory, design methodology, design thinking, interaction design, sensorial experience

**INTRODUCTION**

The first attempts to theorize the forms of digital design thinking have shaped many new graduate programmes in architecture and design throughout the world over the last two decades. The pioneering of new approaches to design computation and digital design by various researchers have formed a bedrock to developing a basis for curriculum. The advent of computer technology dramatically increases the need to integrate digital design in architectural design education. This revives a longstanding research question for instructional designers: How to create a theory of architectural education and design pedagogy in which digital concepts are integrated. Extensive research delineates and addresses the vitality of abandonment of traditional concepts in search for a pedagogical framework to formulate and conceptualize digital design thinking—a rupture which largely defines the dominant model for teaching with digital tools in the design studio. This paper aims at reevaluating this rupture and its related design methodologies, processes and contents in the context of a design studio. The objective of this paper is to determine more direct and intuitive modes of communication between students and digital environments through two consecutive exercises which are the preliminary projects of an interior design studio.

**A FRAMEWORK FOR THE CURRICULUM CONSTRUCTION**

In the following sections, we propose to formulate a theoretical framework and a teaching strategy for integrating physical and digital representation environments in design education. Reevaluating the relation between the basic notions of design thinking and digital tools, we propose a three-layered framework. The framework can be outlined as follows:

1. Digital tools as an extension of conventional tools in design education
2. Redefining the relationship between design

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problems and design tools

3. Sensorial experience as a reflective practice in design

These issues are discussed through two consecutive exercises. In the first part, we discuss the question of digital tools as extensions of conventional tools can facilitate students to develop a reflective dialogue between design thinking process with multiple mediums and tools. The discussions in the second part are regarding the relationship between the design problems introduced in design studios and the design processes of students. The last part emphasizes the role of the body within the sensorial aspects of design reasoning. All three parts constitute a framework to understand today’s design education environment in conjunction with digital tools.

Digital tools as extension of conventional tools in design education

Learning by doing, which involves the tools and materials in learning process, is a term coined by John Dewey ([1938] 1963) and broadly accepted as the foundation of design education. Donald Schön (1983) describes design as a reflective process based on visual reasoning, while hands and eyes are simultaneously working, that creates a dialogue between external representations and the design problem. For developing a studio model, which integrates physical and digital representation environments, digital tools should be introduced in conjunction with the reflective practice of design. Within this context, two consecutive exercises were structured step by step to help students to develop a sense of the dynamic dialogue between their paper-based and digital representations. This was utilized for the students to be aware of their actions. This is also crucial for students to develop personalized design methods by use of digital design tools and to create their individual visual and spatial ideas.

Goldschmidt (1991) explains that sketching consists of a dialectic process which brings about a gradual transformation of images. According to Goel(1995), sketches are mediums of creative transformations of design. Goel (1995) points out that ambiguity is one of the crucial factors because it allows the seeing of new possibilities in the representations, in other words, re-interpretations (Schon and Wiggins, 1992). In order to maintain the reflective practice of design in relation with digital tools, it is necessary to reconsider the way to introduce the qualities of digital tools in terms of design reasoning. In the context of the two exercises presented in this paper, instead of introducing digital tools as the main objective of the studio, we define a particular documentation method. Using this method, students can communicate with their representations. This method provides the interaction of moves and arguments in design process.

Redefining the relationship between design problems and design tools

Various researchers and educators have addressed the need of integrating digital design methods in architectural design education with the emphasis on its discrete nature from traditional paper-based design and the need of reformulating design concepts (Oxman, 2005, 2006). However, with the emergence of new design tools, is it the design concepts and notions that have to be reformulated in design studios or the way design problems are introduced?

The key assumption of the framework we propose is how design problems are introduced in design studios, determine the nature of design processes of students. With the emphasis of the framework on the digital design as an extension of traditional paper-based design rather than a completely discrete phenomenon, we attempt to reevaluate the digital design thinking. Within the process of integrating a new design tool to design education, defining the framework of the design problems based on the logic behind the tool is key to design thinking. And this may serve design student to internalize the new tool as a way of explicating the design thinking and the processes associated with it in a more natural way rather than seeing it as a mere tool.

In the studied examples from two the consecu-
tive exercises in the design studio, students were instructed to follow some tasks step by step. The consecutive tasks were utilized to articulate an analytical model of design thinking. The students were expected to reflect on the process through a particular method of documentation. The general aim, in both defining the tasks and the documentation methods, was to develop ways for students to become aware of computability of their processes and its relation to the logic behind the digital tools integrated to the studio. For the purposes of the inquiry, a conception of space as the intersection of points, lines and planes and how the ways of its definition are dependent upon the representation environment was key to structure the process and the theoretical framework of the exercises.

**Sensorial experience as a reflective practice in design**

The collaboration of the mind, body, and senses set a highly characteristic and personal medium in the course of design processes. This highly personal design medium entails how one perceives their surroundings which is also particular to every individual and designates a quality of personal sensibilities. According to O’Regan and Noë (2001), there is a circular relationship between visual perception and the governing laws of sensorimotor contingency. Bodily experience, both in terms of the space of the body and the body’s use of space, diversifies with the media. However, the concept of representation is derived from the senses in certain formation processes of digital design implications in design studios. In order to include sensorial aspects of design thinking in a design studio, it is necessary to reconsider how to integrate digital tools in terms of design reasoning.

Concentrating on personal experiences, the two exercises mentioned were developed to sustain bodily and sensorial experiences through the assignments. Within this framework, we propose that observations of their surroundings have the key role to develop their own methods while producing a representation of their experiences. From the beginning of exercises, to establish a relationship between body and external representation, the inquiry seeks to develop ways for students to express analytically what they see and how their movement affects their seeing. Thus, the instructors structured the assignments in a way to encourage students to translate their experiences in the physical space into a dynamic representation. In the process of introducing digital tools, students coped with the parameters of the interaction behaviors based on bodily movement. This helped them to enable the reciprocal connection between the digital and physical environments by revisiting the role of the body.

**THE CASE: CAPTURING INTUITIVE MODES OF COMMUNICATION BETWEEN PHYSICAL AND DIGITAL DESIGN ENVIRONMENTS**

A pedagogical approach to the architectural design education for integrating digital design thinking is introduced and discussed. In order to gain critical insight into this approach, two consecutive exercises for design studio were developed. These exercises are: Exercise A: “The Room with a View of Green” and Exercise B: “A Walk in the Room,” are a preliminary project of an interior design studio entitled “Climatic Interiors”. The main project, ‘From the Glass, Green will Grow,’ concentrated on designing a conservatory/glasshouse. The crucial aspect of the project was to propose a scenario that focused on the interaction between the ‘gazer’ and plants and how the user experiences the climatic interior that satisfies distinct environmental conditions. Shifting from physical computing to visual programming; students were introduced to Grasshopper 3D, which is a plugin for Rhinoceros 3D during the tutorial sessions.

The studio involved 17 interior design students (3rd and 4th-year). Participating students were acquainted with computational thinking due to their first year Basic Design education and other supplementary courses such as Design Computing. Therefore, the students were not alien to the notion of computation.
**Exercise A**

Entitled “The Room with a View of Green”, Exercise A comprises four consecutive tasks. The first task assigned to the students was to find and experience a room having a window looking out on any type of green space. The basic instruction for the task was to describe this experience using the site reading tools which were given as one sketch, one paragraph text and one photo (Figure 1).

Students were also to draw one section, one plan and one perspective of the room. The general framework of the exercise was structured to include tutorial sessions of Processing, which is an open-source computer programming language (processing.org/overview). Rather than through presentations that introduce students the programming language externally, the language was presented as a design tool in accordance with the tasks given through the tutorial sessions. The tutorials were designed to benefit from the programming language in systematic, analytical thinking and also to fit into the same time slot within the sequence of exercises. The second task was to make a mapping of the changing interior atmosphere of the room. Students were instructed to observe the gradual change of color and light effects in the room and mark the observations on the section, plan and perspective drawings of the room for six different times during the day (Figure 2-3).

They were expected to develop their own methods for the mapping which benefits from the graphic communication techniques. The third task was to abstract the mappings considering the basic elements of art-point, line, and plane (Kandinsky, 1928) (Figure 4).

The task aimed at benefiting from a concep-
tion of space as the intersection of points, lines, and planes with the aim of creating a connection between traditional paper-based and digital design tools. As students were equipped with processing programming language, they were expected to come up with a code providing opportunities of exploring the transitions of forms, colors and shapes between the abstracted observations for the six different times during the day. The last task was to deliver six different images created in the Processing environment to abstracted observations of the changing interior atmosphere for the six different times (Figure 5).

**Exercise B**

The Exercise B, the second step of the project, is entitled as “A Walk in the Room”. The general task assigned to students is to develop an interactive walk that revealed the changing interior atmosphere through iterative engagement with body and object. In this part, the digital system is planned to include sensors gathering data from the physical environment, an operating system/processing code that transform data and a projection that shows animation as an output of the “Walk”. Thus, consists of the motion sensor (Microsoft Kinect), software (Processing), a display device and a screen.

The first task was to observe the changing spatial relations of the room by designing a walk through the objects and mark their route on the plan drawing with six different designated stops that included the start and the end (Figure 6).

The students were also assigned to draw six perspectives of these stops to show how spatial relations change depending on their positions (Figure 7). The general framework of this exercise was built on tutorial sessions. The sessions were conducted in order to convey the logic behind the calculation process of the motion sensor, instead of giving it as a mere instruction for use. This helped students to understand...
stand how the motion sensor can get a view of the surroundings - the process of its seeing mechanism.

The second task was to establish a relationship between body movement and the output of the last task in exercise A, i.e. re-interpretation of the abstracted observations for six different times during the day within the Processing environment as codes. They were assigned to choose one element or an aspect behind the code that reflects the changing spatial relations by their body movements. This element could be any of the features that they have specified in their code like the transition of the scales, textures, colors or geometry of certain parts. The method was to define a systematic process as rules in the form A → B to show what they change and how they make it.

The last task was to define interaction ways between bodily movement and the code. Gathering depth data by motion sensor, provided the students to translate their experience in their room depending on the distance of the object, into an interactive experience. Thus, they tried out how they can put their principles into action. They delivered six different images created in the Processing environment corresponds to abstracted observations of the changing spatial relations for the six different positions (Figure 8).

**DISCUSSION**

Developing a framework entwining the traditional tools and digital tools to design a progressive out-

Figure 6
The route drawing by Irem Diniz, 2017.
put helped to analyze different mediums and how they can be related in terms of design education. Analysing an environment and abstracting visual and spatial transformations with time and bodily movement was a productive process for students to externalize dynamic interior atmospheric qualities.

In the process of designing a visual abstraction of their spatial experiences into 2D canvases, using points, lines and surfaces, the students translated their spatial experiences into geometries that would easily be applied in Processing graphics. From sketches to mappings, from the aspect of the levels of abstraction and the shifts in medium, the students were able to make correlations between traditional paper-based design and digital design due to the strict definitions of translating the geometries. The Structure of the code was developed with the instructors but since Processing is an open source software, some students were able to advance their coding abilities further.

In the second part of the exercises, the digital interface provided visual feedback through a screen, based on the bodily movements. By moving in four directions in the physical space, the students translated their own “Walk” embedded in that physical place with feedback from a dynamic environment. This continuous manipulation transforms their digital representation of the physical environment into a visual representation. Interacting with their own code enabled the reciprocal connection between the digital and physical environments with this synchronous changes on the display/vertical surface in the physical environment.

Another difficulty in the process was the limited problem-solving capabilities of students due to the limited time of the assignment and the dependence to the instructors’ know-how on Kinect. The code developed to use Kinect only used its depth map to create focus points; yet the code might be improved to use the benefit of many bodily gestures and interactions based on these gestures. Since the assignment was the first time for many of the students to utilize the device, the ability to explore further details and features of Kinect stayed within the boundaries of the code that instructors built. Students had access to one Kinect device during the studio hours. Having access to studio hours or multiple devices would make it possible for the students to test and improve their codes further. The schedule may be arranged to create more study hours with Kinect, where students may try their own sensorial experimentations while they are designing as well.

Based on these issues, we conjecture that the future of design studios might require bringing together a variety of representational practices in the curriculum of design education.

**NOTES**

The framework of these exercises, which are Exercise A: “The Room with a View of Green” and Exercise B: “A Walk in the Room,” were defined by Bahar Akgün
and İpek Kay as a preliminary project of an interior design studio. Entitled “Climatic Interiors,” the studio was coordinated by Deniz Tümerdem, co-tutored by İpek Kay, Bahar Akgün, and tutorial sessions were run by Cemal Koray Bingöl at Istanbul Bilgi University, Faculty of Architecture, Interior Design Department in the fall 2017 semester.

The first task of Exercise A was developed by Bahar Akgün and Lara Mehling for Ornamental Gaze, a design workshop, and borrowed for this course.

REFERENCES