A Comparative Study of Formal and Informal Teaching Methods in the Digital Architectural Curricula

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Design educators are rethinking design education because of the high-demand for the integration of CAD/CAM in the architectural curriculum. However, in traditional design schools with fewer digital courses and more emphasis on the studio courses, an important consideration is how these skills are introduced. With this in mind, and referring to the informal teaching setup, such as workshops and student competitions, this paper describes a study comparing two pedagogical strategies based on a workshop within the curricula and a competition as an extracurricular activity. ICMP method will be used to measure the development of participating students' abilities in analysis, synthesis, integration and critical thinking, under mentor supervision, and enable an evaluation of this approach to the integration of digital thinking, application, and informal design teaching/learning experience in architectural education.

Keywords: architectural curricula, informal teaching, digital fabrication, comparative study

INTRODUCTION
Studio-centered architectural education, originally conceived by Bauhaus, is still dominant in the current architectural design education in Turkey. However, the scope of the discipline can be extended by rethinking the curriculum addressing a certain quality of architectural design education, in line with the demands of the digital age. Parametric design tools are increasingly involved with the use of advanced manufacturing equipment, necessitating an update in pedagogical methods. Therefore, there is an effort to integrate technological advancements contributing to the discipline’s scientific development, as a complement to fundamental studio-based courses. To complement the conventional education system, lecturers are seeking alternative ways to introduce digital design tools through informal pedagogical methods.

Since the digital tools have led to a rise in experiential studies through information sharing via the web, there has been an interaction effect among new media introduction, interdisciplinary and open source code culture, and also between the definitions of the role of professorship and mentorship. The professor, performing the act of teaching within the conventional approach, has now become a mentor who develops students’ abilities in analysis and synthesis, rather than simply showing how to apply knowledge to a specific design problem, or how to use a software program. Clear evidence for this change is the growth of extracurricular setups such as workshops and student competitions. In the con-
text of inserting digital design and fabrication technologies into architectural curriculum, two opposing positions have emerged since the early 2000s (Celani 2012): some consider courses on digital technologies should be integrated into studio courses (integrated studio model), others, that they are independent compulsory courses (discrete studio model).

With this in mind, and referring to the principles of informal design teaching methods and environments as a study case, this paper is a comparative study of two pedagogical strategies, based on the outcomes of formal and informal education setups. To evaluate our approach for integrating digital thinking, application, and experience in architectural education, this paper aims to analyze the process and the outcome of the projects by Izmir University of Economics (IUE) together with their architectural curricula. The emphasis is on the informal learning/teaching of the digital tools through design competitions, focusing on the maker culture. ICF (Issue-Concept-Form) and EDL (Educational Design Ladder) methods, ICMP (Issue-Concept-Management-Product) method measures the development of participating students’ abilities in analysis, synthesis, integration and critical thinking, under mentor supervision, and enable an evaluation of the university’s approach to the integration of digital thinking, application, and informal design teaching/learning experience in architectural education.

THEORETICAL BACKGROUND
The relationship of digital fabrication and computational design enables rapid digitization of product information, and the design is directly linked to the architecture of the architecture. In this approach, architects have control over even the smallest details in the building process, which, as a result, increases their knowledge level of the components of the building (Gramazio et al., 2010). Citing a specific housing example, Botha and Sass (2006) argued that, if previously described in the digital environment, the entirety of an architectural design can be produced by CNC, in the context of material and design rules and the relation of digital fabrication. Botha and Sass (2006) describes possible ways of producing freeform shapes beyond the boundaries of 3D printer, and outside of Euclidean geometry, by adding and subtracting in digital fabrication. In regard to potential developments in materials in architecture, Booth (2009) discusses two axes of digital fabrication tools and methods: material-oriented approaches and performance-oriented methods. Gramazio and Kohler (2008) point to a growing interrelationship between each component in the following pairs: “digital and material”, “data and material”, “programming and construction”. This interrelation between what previously seemed separate, unrelated worlds will lead to transformations and unprecedented expressions in architecture.

The use of digital fabrication, robotic production technology, and other developments underline the key role of such triggers in the emergence of new forms of expression and relationship in architecture (Gramazio et al., 2010). Booth (2009) lists “Gehry Partners“, “Greg Lynn” and “Herzog de Meuron“ as examples of architectural offices using digital fabrication tools and methods as innovations in processes of architectural design and construction. Since the parametric design tools are widely used alongside advanced manufacturing equipment in the practice of architecture, conventional pedagogical methods of architectural design education are likely to require a review. In most cases, the available resources in digital design setups are flexible and are open to change and updating. However, it is important to consider how the need for new skills can be accommodated in more traditional design schools with fewer digital courses and a greater emphasis on studio courses.

In the education literature, some studies on alternative education systems usually refer to open systems or formal/informal education setups. Informal educational setups, there are three main actors: the student, teacher and the institution. This system addresses a more systematic and organized model, in which the curriculum is rather rigid in relation to the content and methodology. The evaluations are
made on a general basis where student work often serve administrative purposes which may not be improvement-oriented (Dib, 1988). It may be said that that the teachers pretend to teach, students pretend to learn while the institutions pretend to mediate. Therefore, this lack of stimulation prevents students actively participating in the process, especially in the current digital era. On the other hand, the informal education system does not necessarily share the systematic and organized dynamics of the traditional formal education systems but rather aspires to produce independent students who are self-disciplined who, under the supervision of a mentor rather than a teacher, develop the strong analysis and synthesis abilities. However, it does not mean that one system is preferred; instead, both systems are complementary. Yalli (1987) states that informal education system can be integrated into a conventional system of education, in which the students can determine their individual learning strategy, and have the freedom to work independently in class and to learn by using the available tools best suited to their interests.

**METHODOLOGY**

In order to reveal the results of the integration of informal teaching methods to formal education setups, a comparative study was conducted on two cases at IUE using the ICMP method. This method is a hybrid composed of the ICF (issue-concept-form) method introduced by Oxman (1994), and the EDL (educational design ladder) method by Wrigley and Straker (2017). The ICMP method includes themes, descriptions and activity lists for each stage of analysis. The method aims to measure participating students’ abilities in analysis, synthesis, integration and critical thinking in both formal and informal setups under the supervision of their professors and mentors respectively, and to provide an evaluation of our approach to integrating digital thinking, application, and informal design teaching/learning experience in architectural education.

The first workshop was organized within the second year architectural design studio curricula, while the second was an extracurricular setup. In the ICMP method, Issue (I), Concept (C), Management (M) and Product (P) indicate a complete design process. In the I phase, discussions on the theoretical background and the method to be followed are realized. It involves the interpretation of the given design scenario, the methods for translating an idea onto a computer, and the ways to communicate through various representational media. This phase is the preparation phase in which the students are subjected to several activities that enable them to understand and analyze the design scenario and its requirements. The C phase involves the development of design idea that would constitute the product content in terms of form, structure, material, and interaction. In this phase, the students are expected to apply knowledge by putting into practice the theoretical aspects discussed in the previous phase. The students identify parts of the design process by deconstructing the methodology into complementary parts. In The M phase, the students finalize their analyses and try to synthesize their previous knowledge and ability with the current design problem and its potential solutions. In this phase, creative thinking abilities are promoted through the integration of methods, unique structures, models, ideas and approaches with the aim of developing design solutions. The P phase indicates an evaluation process, where the students assess the concept, product, and process through a critical assessment of whether these fully meet the requirements indicated at the beginning of the design process.

**EDUCATION SETUP**

Parallel to European and American models, undergraduate architectural departments in Turkey follow various education systems and methods (Pasin, 2017). A studio-based education with discrete complimentary classes has been followed since the outset of the official architectural education system in Turkey. Following discrete studio model, in some universities, drawing and representation courses are
separate, while in others, both integrated into the design studio. CAD and CAM courses were later integrated into the curriculum as technical courses, in which various software was considered mot-a-mot, leading to difficulties in the implementation of digital tools into design education. Students’ lack of design thinking leads to a search for specific answers, rather than defining and following the design process towards generative results. However, these constraints in updating the architectural curricula, have not prevented the emergence of workshops and students competitions as informal teaching methods, in architectural schools.

**Formal Education at IUE**

The Department of Architecture at the Faculty of Fine Arts and Design at IUE is relatively a young department in a recently established private university. Studio-based education is at the core of the program, and it is supported by technical, computer-based, theoretical and history courses.

IUE has a first-year curriculum based on an interdisciplinary Art and Design Studio studio (FFD101/102) set-up, shared with other design departments. Junior students have their first experience of experimenting with design materials and tools and design thinking. The design studio is at the core of architectural education, where students solve design problems through explorations in two and three-dimensional media. Following the development of Bauhaus pedagogical approaches in FFD 101/102, students experiment with color, shape, and materials, with no specific functional or spatial requirements.

In contrast to the emphasis on interdisciplinarity and transdisciplinarity in the first year, the second year design studio focuses on spatial relations, functional requirements, and structural integrity, and on a more architectural design language. The first architectural design studio (ARCH 201) focuses on the design of space, architectural forms and elements in relation to our bodies and senses. Visual, environmental, structural and functional aspects are considered throughout the design process. The second architectural studio (ARCH 202) focuses on architectural design in relation to user, site, and context, considering aesthetic, structural, functional and environmental aspects. It also aims to develop the resolution of form, structure and detailing. Continuing the Bauhaus pedagogical methodology, the second year gradually introduces architectural thinking (Pasin, 2017). After the first freehand and orthographic drawing class in the first semester, CAD is introduced in Computer Aided Technical Drawing (FFD 104). Similar to the first year core FFD101/102, this CAD course reflects the pedagogy of modeling abstract forms without spatial requirements. This course is followed by various design departments in the university and, therefore this interdisciplinary approach introduces a discrete studio model, a separate course supporting the studio (Varinlioglu et al. 2015) consisting of parametric modeling, as well as free-form orthographic drawing techniques designed through parametric tools.

In the second year, Computer Aided Architectural Graphics (FFD 201) covers the basics of 3D modeling, architectural graphics, and professional conventions in a one-semester course (Varinlioglu et al., 2017). As the second and last of the required CAD courses, it incorporates multiple topics. The course introduces the essential techniques of architectural graphics in two and three dimensions and stresses their incorporation and application within the digital technology. CAM, VR, and BIM are partially integrated to CAD course. Due to the limited time for CAD courses in the architectural curriculum, independent workshops are arranged on CAD skills and their applications to design. The sample case studies explained below refer to two workshops for the same group of architectural students following their junior and sophomore education.

**C1: Mission Mars 2024 Workshop**

The students of the second year followed a two-week workshop within the curricula of second-year architectural design studio, entitled Mission Mars 2024: A
Biomimetic Structural Organism (C1) (Varinlioglu et al. 2018).

**Issue.** The students were asked to design a biomimetic structural organism to function as a habitat for the first colonizers on Mars. After the brief was introduced, the students were encouraged to interpret the given design scenario through biomimetic approaches and were supported by seminars on the geographical and climatological climatic conditions, biomimetics, and digital design and fabrication tools.

**Concept.** The final design was expected to be a standalone organism which can not only structurally withstand the geographical and climatological conditions of Mars but also grow, move freely, reproduce and/or exterminate itself. The task was to deconstruct the design process into parts, such as the research on biomimetic entities, studies on climatological and environmental conditions of Mars, exploration of digital design and fabrication tools and representation. The students were then encouraged to apply their theoretical knowledge, supported by the various seminars.

**Management.** The students were asked to design a growing pattern, individual unit, and a system design. In this context, the students integrated several digital design and fabrication methods to develop unique designs.

**Product.** The primary objective of the workshop was to advance their digital design skills in creating unconventional structural formations, but a secondary aim was the development of new growth and living patterns in an extraterrestrial context. Therefore, the second year students of architecture at the university were able to build on basic computer skills acquired in their first year to refer to, interpret and utilize digital design and fabrication tools in the representation of an unconventional project (Halici et al., 2017).

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**Informal Education at IUE C2: FABFEST’17 International Fabrication Competition and Public Festival**

We used the project outcomes as entries in the fabrication festival and concour of FABFEST’17, at the University of Westminster in London. This international fabrication festival is a weeklong celebration of design and making, featuring approximately 50 pavilions built by architecture students from across the UK and around the world. The team had three months to develop, test and fabricate their designs at their home institution before assembly and installation at the University of Westminster. The students emailed the cut files to the university’s digital fabrication facilities, which include Computer Numerical Control (CNC) knives, routers, lasers and robot arms. Thus, the uninstalled pieces were ready for assembly on the students’ arrival. Teams have an academic mentor to guide them, and a Digital Fabrication Liaison assigned from the Lab staff for optimal use of the CNC machines. The purpose of this study was to evaluate the approaches for integrating digital thinking, application, and informal design teaching/learning experience in architectural education. To achieve this, we carried out an analysis of the process and the outcome of the IUE project, together with the architectural curricula. The emphasis is on the effectiveness of the informal learning/teaching of the use of the digital tools through concours, focusing on the maker culture.

**Issue.** After the introduction of the brief and theme “Pop-up City”, the students were given the task of suggesting an alternative experience through portraying a distinct frozen image that represented a city. In other words, the students interpreted the given design scenario through providing visitors with a participatory cyber-experience of physical space, by employing computational tools in the design process.

**Concept.** The design idea was developed through deconstructing the design process into parts, with students applying theoretical knowledge on each design issue, including the form, structure, material,
and interaction. Central London was chosen as one of the inputs, and it was divided into a grid. Hash-tag “London” was searched in relation with specific diameters on each node of the grid via Sonic plug-in for Grasshopper in Rhinoceros 3D. The search results were drained for 24 hours. In order to visualize the quantitative results on the surface created from the grid, the structure was manipulated by lifting and lowering the surfaces from the nodes on the grid within a specific range. At the end of this process, the areas where data is densest determined as being where the pavilion is in contact with the ground and the areas with fewer data constituted a unified shelter.

Management. When the students finalized their analyses, it was seen that the surfaces act together as a structural system; however, the structure was not strong enough to carry its load, and so, to optimize it, several steps were taken. When the loads were assigned, the folded surfaces collapsed due to the moment and shear stress. There appeared to be deformations on the lower parts. Therefore, the structure was optimized accordingly, to transform it into a self-standing pavilion. Three margins were left on three sides for each triangular unit, and three margins were left for each individual triangular panel. The panel margins of the were calculated through a distinct trigonometric equation scripted in Visual Basic component on Grasshopper. These equations resulted in degrees that determined the degree between the panels. In this context, the students integrated several digital fabrication methods to develop a unique joint design for the folded pieces.

Product. The students thought that the output lacked interaction with the visitors, which was contrary to the requirements, as indicated by the students at the Issue (I) phase. Therefore, a graphical display was generated and projected onto the pavilion in order to give visitors an impression of the transformation of real-time data into a tangible form. In the graphical display, the real-time data was drained for 22 distinct frequently visited sites in London. As Twitter data constantly fluctuated, the connections between these nodes also changed. This kind of form-finding process illustrated the fluidity of the form in relation to the real-time data on a dynamic scape.

This paper concentrates on a comparative study of the learning outcomes based on students’ pavilion designs in C2. The focus group consists of 5 architectural students, who participated the formal education system as explained above, i.e. the C1 within the framework of the curricula, and, in terms of informal education approach, participated in the C2 as an extracurricular activity. Until C2, they had received only a basic level of digital design, fabrication and representation skills in both software and hardware.
RESULTS AND DISCUSSION
The exploratory analysis of each case was based on the ICMP method, which consists of students’ interpretations of design problems through design solutions, developing concepts by applying knowledge to the given scenarios, analyzing and synthesizing the structures/models/ideas/approaches through creative thinking, and critical evaluation of the effectiveness of the product, concept and process. 5 students who participated in both workshops completed an online questionnaire with 27 items. The results have shown that the students had a reasonable knowledge and experience of Rhinoceros 3D while they were both concerned about their competency in Grasshopper. Students group reported only a small number of difficulties while using Rhinoceros and Grasshopper. However, students indicated that they experienced many challenges during the digital fabrication. The student group indicated that Rhinoceros, Grasshopper and digital fabrication tools, had increased their creative thinking. They also stated that the process was very exploratory and that the design process and the product were very much enhanced by using Rhinoceros, Grasshopper and digital fabrication tools. They also considered that these digital tools should become more integrated into architectural design studios.

For the C1, it can be inferred that the students have had a reasonable knowledge of Rhinoceros 3D and basic knowledge of Grasshopper before the workshop. They were very much concerned about their knowledge and experience of these digital tools before the workshop. However, although they had only a basic knowledge of 3D printing, they were less concerned with this deficiency than with their knowledge of Rhinoceros 3D and Grasshopper. The students also were moderately successful in applying their recent knowledge to the design process after the seminar on parametric modeling. They faced few problems while using Rhinoceros 3D, and almost no problems with the 3D printer, but many problems while using Grasshopper. The students believe that digital design and fabrication tools have enabled them to develop unique structures, models, ideas, and approaches. Rhinoceros 3D and 3D printer technology affected their creative thinking, unlike Grasshopper. This is possible because of their many problems with Grasshopper, which resulted in a pessimistic view of their development of creative thinking. For the C2, it can be seen that the students started to gain confidence in their knowledge of digital tools after previous experience in a workshop setup. They indicated having very little knowledge and experience of interactive tools before the workshop, and many concerns. It was observed that the concerns about digital tools have decreased compared to the C1, and all indicated that they have found the process a great opportunity to explore.
Applying the ICMP matrix onto a design process enabled a feedback-based process of evaluation for both the students and the educators. C1 was realized within the studio setup as part of the curriculum, while C2 was realized outside of the studio setup. The difference between the results may be seen as an indicator that, even though the design studios are locations for formal architectural education, they were also able to accommodate informal requirements when accessible to the students. Although mentor technical support decreases in informal setups, the organizing principle is the concept of inquiry, which enables students to explore through the integration of a variety of learning activities. They demonstrated respect for the values of others, democratic procedures, and an emphasis on a collective practice by individual theorizing. Therefore, mentors become facilitators of student learning, rather than as transmitters of knowledge. The students are actively encouraged to take ownership of their own learning methods by individual inquiry rather than formal tutorials. These results show a need for such informal education setups within the formal setups in order to increase students’ learning motivation, their ability to acquire new skills in a short period, and also to acquire new skills in the design process. The qualitative analysis of students’ abilities in analysis, synthesis, integration and critical thinking is considered to contribute to a better understanding on students’ performance in dealing with the increasing complexity involved in the digital way of making.

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