

TRANSFORMATION OF BIO-PATTERN TO POLY-PATTERN AS A BASIC DESIGN STUDIO EXPERIENCE ¹

BİR TEMEL TASARIM STÜDYOSU DENEYİ OLARAK BİYO-ÖRÜNTÜNÜN POLİ-ÖRÜNTÜYE DÖNÜŞÜMÜ

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Öz: Amaç: Temel tasarım 1 stüdyosunda biyo-örüntülerin poli-örüntüye dönüştürüldüğü çalışma sürecinde ve sonucunda elde edilen eğitim kazanımlarının değerlendirilmesi ve üretken tasarımın bu aşamada üretilebilirlik düzeyine dair bir araştırma yapılmasıdır. **Yöntem:** Araştırma yöntemi çalışma sürecinin gözlenmesi, sonuç ürünün çalışma amaçlarına uygunluğunun ve süreçte hedeflenen kazanımların elde edilebilirlik derecesinin değerlendirilmesi ve 50 katılımcıya uygulanan anket verilerinin tartışılmasından oluşmaktadır. **Bulgular:** Katılımcıların neredeyse tamamı çağdaş tasarım yaklaşımlarına dair bilgi ve deneyim elde etmiştir. Çoğu öğrencinin birim formların tekrar ve benzerliğiyle üretken bir tasarım gerçekleştirebildiği, beyin-el koordinasyonu aracılığıyla yapılan çalışmanın el becerisine katkı sağladığı görülmüştür. Katılımcıların neredeyse tamamının form ilişkileri ve doku arasındaki ölçek geçişlerinin uygulanması aracılığıyla, yaratıcılığı harekete geçmiştir. Çoğu öğrenci grup içerisinde ve/veya yürütücülerle birlikte yaşanan tartışma ve sorgulama ortamının öğrenme sürecini desteklediğini belirtmiştir. **Sonuç:** Eğitimin ilk yarıyılında “düşük teknoloji-yüksek düşünce” ekseninde üretilebilirlik düzeyine dair deney sonucunda, poli-örüntünün nitelikli biçimde üretilebildiği görülmüştür. Katılımcıların üretken tasarımı beyin-el koordinasyonu aracılığıyla geliştirmesinin verimli olduğu gözlenmiştir. Deneyimle öğrenmeyi destekleyen uygulama, bilgi ile üretimin birleştirilmesi ve parçaların bir bütün olarak bağlantılandırılması kazanımlarına katkıda bulunmuştur.

Anahtar Kelimeler: Biyo-Örüntü, Poli-Örüntü, Üretken Tasarım, Temel Tasarım Eğitimi, Mimari Tasarım Eğitimi

Abstract: Aim: The aim is to evaluate the learning outcomes of the course of studying the transformation of bio-patterns to poly-patterns and to conduct research on the producibility level of generative design. **Method:** The research method involved observation of compliance of final product to research objectives, the attainability level of the gains targeted during the process, and questionnaire survey which was applied to 50 students. **Findings:** The research conducted on an experiment related to producibility level, in accordance with the “low technology-high thinking” approach, showed that generative design can be developed qualitatively by repetition of unit forms, through hands-on learning. In design process, where shifts were made between different scales, from form to pattern, it was concluded that the creativity and the fine-motor function of most of the participants had improved. **Results:** It was observed that the development of generative design with no technology but through brain-hand coordination was effective for the students at the first semester of their education, in terms of developing their skills and creativity. The exercise that support the experimental learning, contributed to combine the information and practice for developing the achievement of connecting the parts as a whole.

Key Words: Bio-Pattern, Poly-Pattern, Generative Design, Basic Design Education, Architectural Design Education

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INTRODUCTION

Today, the contemporary design approach is related with certain concepts, such as evolutionary biology, artificial intelligence, and complexity theory, and different design disciplines are integrated with biology and technology at various levels, from discourse and morphology to practical necessities and production (Lim, 2011: 12). Biomimicry is the technological implementation of designs seen in nature to solve problems in the fields of architecture, engineering, and others (Muel-ler, 2008: 68). Biomimicry is a concept that was first put forward by writer and science observer Janine M. Benyus believed that the models in nature should be imitated (Tavşan et al., 2015: 492). As implied from the word itself, biomimicry is an approach that aims to generate solutions through the inspiration of nature. In this approach, examples from nature are used to solve problems, based on the assumption that nature has the inherent ability to self-cope with emerging problems.

Advancements in technology have opened up new methods for application in virtually all disciplines, including architecture. The way of thinking and expression of the people who grew up in 21st century which is different from past eras because of digital technologies and communication has changed (Kalaycı, 2015: iv). It is deceptive to think that the opportunities of technological developments would not

affect the representation, theory and practice of architecture (Yürekli and Yürekli, 2004: 10-11). For many years now, the biomimicry approach, coupled with technological methods, has also been used by professionals as an architectural design tool. In the architectural discipline, certain basic dynamics involving organization, environment and human behavior in interaction with digital, productive or bio-design approaches have consistently proven to be valid approaches, and bio-formation and bio-production in design serve as rich inspiration sources, in terms of creative solutions, on a multi-disciplinary level. According to Michael Pawlyn, who is the head architect of the most well-known project designed by biomimicry in architecture, the Eden Project in Cornwall, England, biomimicry depends not only on the shapes of organisms but also on how they operate. He prefers architecture rather than biology as the discipline of choice to bring out the creative potential of architecture.¹

Nature's use of trial and error and the development of evolutionary solutions can act as a valuable resource and can inspire the design process. Bio-design work opens up a broad range of possibilities and sharpens the understanding of totalities and details. It provides a new method and perspective in the realm

¹ <http://www.arkitera.com/haber/19038/mimaride-biyomimikri>



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of creative work (Roshko, 2010: 545). Mike Jones and Jocelyn de Noblet defined bio-design as the transformation of a form that develops out of the environmental harmony of organisms into a product-looking form (Chiu and Chiou, 2009: 3627). Bio-design institutes and system centers whose technological infrastructure has been inspired by biology have been established throughout the world, and their numbers are increasing.

This approach has started to take on greater significance in the field of architecture, as over time more experience with the approach has served to increasingly support its creative potential. There is also a growing body of research identifying various obstacles to the employment of bio-design as an architectural design method (Zari, 2007: page number does not exist). They are useful to adapt bio-design to the design studio. The “designing” activity is learned in design studios, where creativity is set free within the natural boundaries of the field, using the method of experience-by-doing under the guidance of a studio advisor(s) (Schön, 1988: 5). In this framework, bio-design is a process wherein creativity is supported through experience in order to develop awareness during the course of learning the design.

In the process of production-education and creation in which the ideas transform into design, the expression of “concept” is frequent-

ly used. The conceptual thinking which has phases as interrelating, constituting sense, communicating, analysis-synthesis and abstraction is a basis for concepts that matter in design production and creation (Bekdaş and Yıldız, 2018: 325-326). Basic Design studio, whose process operates along the lines of conceptual scenario and its visual expression, has quite a fundamental place in design education. Basic design, an introductory course for all disciplines within the design field, focuses on abstract, cognitive thinking, which is the most important tool of designing practice for problem solving. In basic design, the approach starts at the concrete level, proceeds to the abstract level, where ideas are generated, and then returns to the concrete level via cognitive thinking (Sarioğlu Erdoğan, 2016: 10). Within the context of generating solutions to design problems through the inspiration of nature, Basic Design studio can be seen as a convenient environment to experience bio-design, in the sense that it supports creativity through cognitive thinking, and that it reflects the relations between abstract-concrete expressions onto the final product.

Transfer of knowledge in the field of bio-design should be carried out within the basic design studios, where the primary aim is to teach design principles, especially for newly starting students. In the basic design studios, students acquire the ability to think and de-



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sign with inspiration from nature and to build products through digital design-based software, and overall, the students will enjoy an education that keeps pace with the contemporary age and in some cases, that even goes beyond it. However, in the first year of architectural education, computer-aided design education is not offered, rather it can generally be delayed to subsequent semesters, as the primary aims in the first year are to teach students the skills to depict the ideas and approaches of design by hand and to acquire the ability to think in three dimensions. Students are expected to pursue these goals in basic design studios. Since basic design studios allow transitions between abstract and concrete expressions through cognitive thinking, they are quite useful in exploring and experiencing the creative potential of bio-design.

In the paper, experimental work which is carried out on bio-patterns and poly-patterns consistent with the type of design education that embraces the experience method of producing by doing, and its results are evaluated. As previously noted, the achievements targeted for this study were expected to overlap with those targeted through the Basic Design 1 studio.

AIM

The aim of this study is to evaluate the educational acquisitions achieved by participants

(the students) under the guidance of advisors, and to conduct research on the productivity level of generative design at this stage by evaluating the form relations, repetition-similarity and material potential that resulted from the application of creative methods in the working process, as well as from the process in which bio-patterns are transformed into poly-patterns. Furthermore, the probability of the achievability of the targeted gains in this experimental research is also assessed.

CONTENT

In the paper, following the introduction and a theoretical research regarding the relation between bio-design, architectural design and basic design in order to create a background, the case study conducted is discussed. The research in the case study is carried out within the framework of an evaluation of the working processes of 160 participants, the final outcomes, the questionnaire on targeted gains applied to participants, and the observations of the process governing the Basic Design Studio 1 course offered by the Uludağ University Department of Architecture.

The evaluation of the working process and the final outcomes that are grouped according to the production method of the poly-patterns, related to the aims of the research and the targeted achievements was made by advisors, and the questionnaires applied to the



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students were used to evaluate the working processes and the overall research, and feedback was received from them. In discussion, the results of the study are discussed comparatively with the results in the literature and the basic design studies aimed at production of poly-patterns by the transformation of bio-patterns are evaluated from the perspective of such criteria as the abstraction ability, utilizing the potential of the materials, dominant unique forms, the organization and transition between the layers, forms and spaces. These criteria are determined according to the study purposes and targeted gains in the process.

RESEARCH METHOD

The research method involved observation of the working process, evaluation of the compatibility of the final outcome to study purposes and examination of the achievability level of the targeted gains in the process by the advisor, as well as evaluation of the questionnaire data from 50 participants. The observations made by the advisors following the seminar given in the studio at the beginning of the research involved the research and working process on bio-patterns and the evaluation of final products via an open jury system.

For this study, it was considered important that the students be able to evaluate the research system, the reasons for choosing the

designated bio-patterns, the generated ideas, and the problems in implementation, to identify the creative alternatives to the problems, to determine the material potential creatively and to evaluate the conformity of the produced poly-patterns to the expectations and objectives.

The questionnaire was applied to examine the perceptions, awareness and learning acquisitions of the participants and was based on a 5-point Likert scale, with the possible responses being certainly agree, agree, neutral, disagree, and strongly disagree. Along with the questionnaire, the students' opinions on their learning acquisitions, the studying process, techniques, materials used, implementation and learning process were taken.

RESEARCH RESTRICTIONS

The main restriction of this study was that the participants included only those students enrolled in the Basic Design Studio 1 course offered by the Department of Architecture of Uludağ University, and that the study lasted only 3 weeks, as this was the designated amount of time allocated for work within the studio program.

RESEARCH PROBLEM

A practice was carried out that is discussed in the paper wherein a number of existing bio-patterns in nature were transformed into



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poly-patterns in order to experience bio-design through hands-on learning. This practice is seen as a preliminary step to the introduction of digital design-based education and computer technology for students participating in the basic design studio. Therefore, the research problem is to evaluate the results of the “poly-pattern from bio-pattern” study using hands-on learning and the contribution of the study to the basic design course and first grade architectural education through creative thinking, experiences and connecting different knowledge and materials in order to produce a design outcome.

RESEARCH HYPOTHESES

The research hypotheses intended to contribute to design process and design education that are determined in accordance with the research problem are as below;

- The seminars and research on generative design, bio-design and bio-pattern can improve awareness and information of students
- The study can provide an opportunity to study different subjects of basic design lessons related to each other, to implement this theoretical information and to achieve the targeted gains in the studio.
- The study performed through brain-hand coordination, instead of computer software, with different forms, patterns and materials in

different qualities can contribute to skills of connecting different parts and trigger creativity of students.

- The group work and the feedback environment can contribute to empathic approach and can enrich the learning-experiencing process through different “role-parts”.

THEORETICAL FRAME

Basic design, if properly reconsidered, will be the best pedagogical tool for teaching the design approach that is based on the complexification of the process, the problem setting, the product that should be completed and the impact of the project (Findeli, 2001: 12). The aim of basic design education is to give students without a design background the opportunity to create a composition through the organization of forms and elements, to use the materials, to execute designs, to express themselves concisely and clearly, and to achieve functional communication. The research shows that basic design studios contribute to helping students have a greater awareness of the environment and respond in a creative and effective manner, discern variations, develop their acumen and improve visual expression skills (Usta et al., 2000: 41). In the first semester, when the ability to engage in original thinking tends to atrophy as consequence of the assessment and evaluation system in Turkey, students experi-



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ence confusion in uniquely forming their approaches to their living environment, spaces and pattern, in nurturing the development of their imagination and in designing a product. Basic design courses help to alleviate this confusion, in that they open the channels of perception and creation. Design education which aims a multiple awareness achievement, enhances the sensitivity and perceiving competence of students.

The importance of development of creativity in architectural design education and process is emphasized in different studies (Özgencil Yıldırım, 2003: 36, Arıdağ and Aslan, 2012: 58, Onur and Zorlu, 2017: 545-546, Soliman, 2017: 205, Royalty, 2018: 138). Especially in the first year of architectural education, it is crucial to develop the design skills and creativity (Arıdağ and Aslan, 2012: 50). The first year architectural studio with its unique difficulties, subjects and excitements is a place that the students encounter with the uncertainty and varieties of architecture and get surprised, while the coordinators face this astonishment again and again (Şenel and Sönmez, 2017: 4). Studio is a place that the information is learned by doing, a learning-teaching environment and the affects of expressionlessness, uncertainties and theories-rules that are not concrete enough are felt in this environment (Ulus Uraz, 1999: 13). Spiritual or formal, different methods followed in design

education contribute to production of unique ideas, connection of different parts, development of analysis-synthesis competence of students (Onur and Zorlu, 2017: 546-552). These methods should focus on supporting creative thinking of students by revealing their individual tendencies, distinctness and uniqueness (Arıdağ and Aslan, 2012: 51-56, San, 2008: 24). By the reason that creative thinking is not making something out of nothing, the perception manner of the designer becomes important with that the designer as a recipient is supposed to form what he/she perceives (Özgencil Yıldırım, 2003: 36). In a description in the literature, creativity is to make new combinations with the knowledge that is accumulated in the memory by an intense awareness and consciousness (Arıdağ et al., 2000: 16). Creativity is a unique happening comprised between spiritual entity and material world (Tunalı, 2009: 62). Design process is a cognitive process that becomes subjective in emotion-imagination, information, understanding, connecting, awareness and synthesizing phases (Özgencil Yıldırım, 2003: 39). Intensity of intuition and information of the architect enriches the architecture (Arıdağ et al., 2000: 15). Different personalities of every student become prominent in architectural problems, the movement of body (hands) and the intuitional feelings become a whole (Uluoğlu, 2000: 35). In this framework, it is important to stimulate individual tenden-



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cies and differences for developing creativity. “Learning design”, which corresponds to the “teaching-learning” process, is a “scene” in which the individual actively participates, in an interactive manner, in the learning environment (Koper and Tattersall, 2005: 7).

Basic design education, which involves developing students’ natural tendencies, as informed by their individual experiences, offers the most “reliable” environment for fostering the development of the student (Gökaydin, 1990: 38). In this scope, the studio practices should provide sufficient grounds from which to develop individual tendencies and the preferences of the participant (student). Olivier and Tattersall (2005: 30-31) discuss the concept of “role-part” in the studio environment. Accordingly, role-part includes a reference to a role and a reference to an activity in the design environment. In the components of role-part, roles include predefined learner and staff roles, but learning designers can define other roles of their own, derived from these basic two roles. In education systems related to art, the master-apprentice relationship contributes to the development of the individual and coincides with the relationship between advisee and advisor (Ünver, 2015: 113). In design, which is an interpretational and dynamic system, students try to understand the connections between information layers together with the studio instructors (Arıdağ and

Koş, 2015: 104). Yürekli and Yürekli (2004: 23) define the design studio as a structure that enriches by the past experiments, way of thinking, discussions and interactions of the designers, a “black hole” that the formation of design is ambiguous. Therefore, with the information acquired in basic design studios, students can orient designs in an environment better suited for facilitating expressiveness in and reflection on their way of thinking. The various purposes behind basic design education include learning the basic language of design, educating the personality, understanding and building relationships among design constructs, and understanding how to create relationships with the environment through design (Besgen et al., 2014: 430).

Design process is based on manipulating form and information together in materializing formal evolution (Arıdağ and Koş, 2015: 104). In this framework, basic design is a studio education and environment that supports design process. By the reason that the interaction that is created by the images in studio environment supports creative thinking by new experiences, design studio have the characteristics of the “heart” of education (Özgencil Yıldırım, 2003: 38). Experimental learning is an important part of design education (Soliman, 2017: 207). It is important to produce methods that support connecting the abstract-concrete, to develop the imagination



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devoted to stimulate the creative design process and the creative thinking by experiences in the studio. It is necessary to integrate the architectural information that is taught fragmentary to make the design in the architectural studio (Bekdaş and Yıldız, 2018: 333). The concept that constitutes the whole in architectural design is the fiction and how to set which of the parts should be explored. In this framework, developing the achievement of connecting should place a particular importance in studio education with the aim of fictionalizing the parts as a whole (Özgencil Yıldırım, 2003: 39).

At this point, the methods with respect to conducting design education in the studio gain importance. While some parts of the architectural education that is fragmentary taught support the of theoretical substructure and some support technical information and expression language, basic design education and design studios constitute the part that aim to develop visual, perceptual, sensual, critical and cognitive aspects, feeding artistic and aesthetical dimensions (Onur and Zorlu, 2017: 543). The achievement of “seeing, hearing, touching and tasting” is between the initial aims of design education to make the student perceive and form his/her environment (San, 2008: 25). Even if having the education of art/production is the prior condition to gain the knowledge, the information and methods

used for understanding and interpretation are beyond the basic knowledge (Kalaycı, 2015: 121). Understanding and interpretation are in direct proportion with the effort endeavored for intellectual, emotional and imaginary development (Kalaycı, 2015: 122). So although the theoretical information is the initial phase, the methods devoted to feed intuition, intellectual and emotional development matter to experience this information and to support the creativity that is necessary in this process. Basic design studio should be organised again and again intended to different experiences and support sensual and emotional development through the feedback gained from the students.

Different universities use different approaches in the courses carried out in basic design studios. Uluoğlu (2000: 58) emphasizes that if there can be a specific way of teaching design, the problems of teaching would arise from; a) that there is no consensus on the content of design knowledge to be taught at architecture schools at different levels, b) the development of methods and tools for the teaching of design. One main difference in approaches involves the degree to which the abstract or concrete is emphasized. In some universities, it is carried out in an abstract manner, in terms of space (abstract) and environment (concrete) conceptualization, while in others, it might be more concrete and en-



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vironment oriented. Another approach seen is the use of a basic design for different departments as a common core course, especially at newly opened universities; but the challenges of collaborative work and maintaining the genuine point of view of each discipline might obstruct the working process (Sarioğlu Erdoğan, 2016: 10). In this context, developing specific rules for basic design studios is neither correct nor possible. It is important that the development of studio management take place within the framework of the suggestions on the works of basic design courses and the criticisms about implementation and that evaluation methods be made considering the general approaches used in architectural design studios at the university.

The basic design courses offered in the Department of Architecture of Uludağ University, where the study is conducted in accordance with their specific methodology, are carried out in two terms; the fall and spring semesters of the first year, and include Basic Design 1 and 2 studios. Targeted achievements for students enrolled in Basic Design 1 studio are to develop research skills, to gain the ability to generate creative solutions to problems, to create multidimensional/all-purpose/open-minded thinking, to learn and be able to apply main presentation techniques, to strengthen visual expression, to gain the ability to develop an empathic approach to oral

and written communication, to recognize and define different design process approaches, and to learn basic design principles/concepts and their applications. The Basic Design 2 studio focuses on theoretical knowledge transfer and implementation processes for the three-dimensional use of the required design elements and principles within the context of the development of three-dimensional thinking, and in continuity with the Basic Design 1 studio course, Basic Design 2 further focuses on the development of the ability to solve design problems. The aim of the basic design education should be to reveal and develop the creativity of the students and a studio environment that perpetually changes, develops and enables different experiences should be targeted. (Arıdağ et al., 2000: 16). In the student-oriented environment, methods should be tried in order to make the students explore themselves (Ulus Uraz, 1999: 13). In this scope, the design work discussed in this study, is a method and practice that is experienced for the first time in the studio environment that is student-oriented as stated in the literature. The program regarding the conduct and targets of the studio is open to change at any moment. The aforementioned instant changes that are lived from time to time are directed according to the instant feedback received from the students.



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Using different materials and techniques helps students to improve their creativity and enables them to form a background for their future studies and courses (Besgen et al., 2014: 431). Different exercises and methods are implemented in different institutions in order to develop the intuitive and creative thinking skills of students and make them gain experience through different parameters as body, time, space (Arıdağ and Koş: 2015, 101-105, Onur and Zorlu, 2017: 545-552, Uysal and Arıdağ, 2012: 119-129, Arıdağ and Aslan, 2012: 53-54). Relations between knowing and doing are very crucial in the field of design to exercise the design by the content of knowledge (Uluoğlu, 2000: 58). As a method that we have encountered in this context, the transformation of the inherent qualities of the “paper-fold” into a prototype that has wide practicability and proper transition from macro to micro scales to create a design area that unifies the disciplines of architecture, interior design, product development and fashion, serves to foster improvisation. Today, this technique, which is referred to as the “low technology-high thinking” (radical-retro) approach, as opposed to computer-aided design and production, is a process-based exercise that relies on basic coding and brain-hand coordination, rather than on software (Vyzoviti, 2012: 10). Forms produced through “paper-fold” have the potential to create an algorithmic condition that can be

transformed into patterns and surfaces via a series of repetitions created by the unification of method and visual expressions (Vyzoviti, 2012: 8,9). To generate designs and alternative compositions in basic design education, algorithmic rules composed with basic design principles are quite useful tools (Özen Yavuz and Yıldırım, 2012: 310). The studio exercise discussed in the paper is developed through this framework to connect different parts of the basic design information learned.

THE METHOD and DESIGN of STUDIO RESEARCH on TRANSFORMATION of BIO-PATTERN to POLY-PATTERN

The research carried out within the framework of the Basic Design 1 studio largely involved the students creating two-dimensional designs, where the aim was to produce a productive pattern by effectively using the repetition-similarity of forms according to the program. In the first phase of the study period, to achieve one of the target acquisitions of the studio, a seminar was given by the advisors to inform the students about the contemporary design approach concepts of generative design, bio-design, bio-formation, bio-production and implementation and how to recognize different design process approaches. In addition, the seminar also taught the concepts of repetition-similarity, texture-pattern, bio-pattern and poly-pattern, which are learned and practiced in the studio, and



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how they were related with each other, and their actions and limitations were explained. Once the students had gained a certain awareness of the subjects as a result of the seminar, they were directed to explore bio-patterns for their research and to think about the transformation process towards a poly-pattern. The main target acquisitions of the research process were to help students gain awareness about current design approaches, to encourage them to research, learn, and think, and to develop in them an empathic approach via the doing-by-experiencing method and group work, and to cooperate.

The research was premised on the bio-pattern determined by the participants. From this starting point, the students were expected to apply the generative design approach, which was to include the repetition and similarity of the generative unit forms obtained after completion of the abstraction process involving the pattern and material, to create a poly-pattern. In carrying out this process to create a poly-pattern, the students were expected to apply their knowledge on the relations of generative unit forms and the association of repetition-similarity with generative design and to evaluate the material potential with creative methods.

The materials allowed for the implementation were restricted to white file paper, white bristol cardboard, model cardboard and ac-

etate for transparent patterns. The intended aim behind the use of these materials was to give students the opportunity to utilize the potential of paper and cardboard by applying certain methods, like cutting, folding, re-opening, wrinkling, compressing, and unification, to trigger their creativity, and to teach them how to develop a pattern from materials that have a plain pattern, by ignoring the use of color and different surfaces, and instead transferring and reading the pattern simply and clearly over white-transparent colors. A further aim of this study was to help students re-discover and re-experience the feasibility-possibility of the materials used in the process of conducting their works, which involved an experimental application area, where production of the material was carried out in a one-to-one manual fashion and shaped together. The use of paper and cardboard, as larger, thinner, thicker and harder materials, can activate creativity in scale, use and pattern as Besgen et al. (2014: 430,431) stated.

The process-based implementation started with informative seminars before moving on to the studio, where the students decided on their bio-patterns and engaged in mutual interaction and feedback with the advisors. The feedback was largely related to the topics of the abstraction of the determined bio-patterns, material selection and feasibility, creation of generative unit forms by applying



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the generative design approach based on the repetition-similarity principle, how to come up with a poly-pattern and the producibility experiments. At the end of the process, the students were expected to present a product that had been created through the proper use of the applications related to the Basic Design 1 studio.

A BASIC DESIGN STUDIO EXPERIENCE “FROM BIO-PATTERN to POLY-PATTERN”: FINAL OUTCOMES

In the process of abstraction of bio-patterns, the generative unit forms constituting the poly-pattern were transformed into organic units consisting of curvilinear lines/planes, while some appear as sharp units consisting of planar, fractured lines or planes. In some of the implementations, linear forms, while in others, planar forms, are dominant, and there were also others in which the planes were transformed into volumes. In the interpretation of bio-patterns, transparency was observed in some of the practices. In the poly-patterns, where planes and volumes are used in either a positive or a negative manner, the possibilities and capabilities were found to influence the works, and in the pursuit of producibility/expressibility of transparency or organic volumes, it was observed that the stu-

dents would return to the beginning to make a fresh start. The examples of the bio-patterns and poly-patterns of the final products produced from the groups, which consisted of four to five students, can be seen in the following parts. The practices were examined and grouped according to similarities in the search for forms and the method followed during the production of poly-patterns, which was carried out within the framework of repetition of generative units using the generative design approach. The criteria for classification of the evaluated examples are according to the production method of the poly-patterns as can be seen in Table 1. This classification is made by grouping the examples that consist of; a) the repetition of similar planes and the volumes that are produced by transforming these planes by extending, stretching and heightening the planes, b) layers and layers that are produced through repetitive transparent and solid unit forms that are contrast, c) repetitive similar straight linear or curvilinear planes, d) the repetitive planes that are produced by folding the cardboard or bristol carton with changing dimensions, e) the repetitive unit forms that are produced by cutting the cardboard or paper into small pieces and folding them (Table 1, Figures 1-6).



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Table 1. The Classification of the Poly-Pattern Examples

THE PRODUCTION METHOD of POLYPATTERNS	BIO-PATTERNS		Related figures
The repetition of similar planes and transformation of the planes into volumes by extending, stretching and heightening	amethyst stone	iguana skin	Figure 1
Layered designs, Repetition and contrast of transparent and solid unit forms	bone marrow	honey comb	Figures 2-3
Repetition of similar straight linear or curvilinear planes	kidney stone	cabbage section	Figure 4
Layered designs, Repetition of similar folded planes with changing dimensions	mountain surface	bird feather	Figure 5
Repetition of similar linear unit forms with changing heights	lizard's foot	gecko hair	Figure 6

The poly-pattern that is produced through the repetition of similar planes and transformation of the planes into volumes, seen on the left in Figure 1 was based on the amethyst stone as bio-pattern, while the one on the right was based on iguana skin. These practices are similar to each other, in terms of the approach to the process, as the small units were transformed into the growing planes and volumes, and the materials were used after breaking or folding. In the first work, a gradually rising, sharper and rough pattern was formed by folding, breaking or positioning the cardboard

in a horizontal direction. In the second work, the height of the pattern proceeding towards negative volumes remained at a certain level, and it was transformed into a rough but less sharp pattern compared to the one on the left side. The poly-pattern examples, where planar forms grew sustainably and transformed into increasingly positive/negative volumes, demonstrate a repetitive structure, created through a generative design approach, where the forms were constituted of triangles or fractured generative units (Figure 1).

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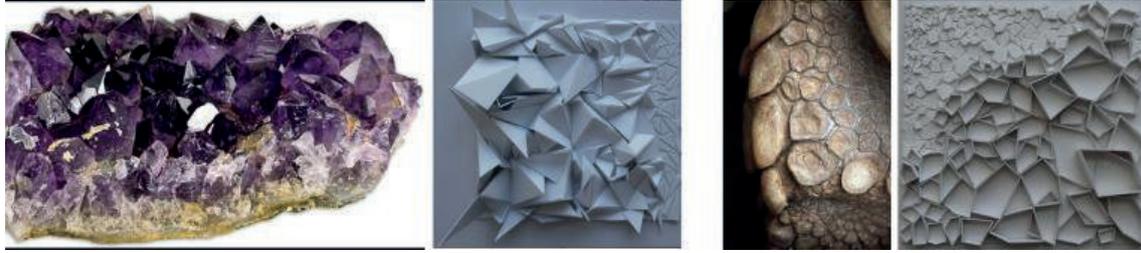


Figure 1. The Poly-Patterns Produced by Amethyst Stone and Iguana Skin as Bio-Patterns

As seen in Figures 2 and 3, transparency gained significance in some parts of the practices in relation to the necessities of the bio-patterns that are produced through layers, repetition and contrast of transparent and solid unit forms. The poly-patterns inspired from the bone marrow pattern shown in the figure above and those inspired from the honey comb pattern shown in the figure below were developed by means of interpreting the vacancies as transparencies via the bio-patterns, which feature a productive system consisting of a solid-void structure. Both poly-patterns consist of opaque and transparent layers pro-

duced by white bristol cardboard and acetate. The poly-pattern shown in the figure above was made up of the transparent spaces of the original organic units, while the one produced from honey-comb was made up of geometric transparent units, depending on the requirements of the bio-pattern. On the other hand, it is also possible to interpret the white opaque layers in the poly-patterns shown below as curvilinear forms, and as short and straight linear forms in the patterns shown above. These applications feature homogeneous poly-patterns consisting of opaque and transparent layers (Figures 2, 3).

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Figure 2-3. The Poly-Patterns Produced by Bone Marrow and Honey Comb as Bio-Patterns

In the poly-pattern examples where similar straight linear or curvilinear planes are dominant, it can be seen that the cardboard was used in strips to create vertical and curvilinear forms in a short and straight line/planar manner. The poly-pattern from which the microscopic image of the kidney stone was interpreted as a bio-pattern, consisted of short, vertical planes or short and straight lines, depending on the point of view. The short and

flat planes created generative units in similar dimensions, which contrast with each other in terms of directions. In the work produced from a cabbage section, bristol carton was cut into short or long strips and used as curved lines. By varying the space between the strips, the poly-pattern structure was formed by the generative curvilinear units and the spaces between them (Figure 4).

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Figure 4. The Poly-Patterns Produced by the Microscopic Image of the Kidney Stone and a Cabbage Section as Bio-Patterns

The works in Figure 5 where the similar folded planes were repeated with changing dimensions, the poly-patterns were implemented using cardboard, and small planes were transformed into larger planes in a continuum. The method of folding and re-opening the cardboard was applied in two applications based on the bio-patterns, as can be seen in the mountain surface on the left and the bluebird feathers on the right. The poly-pattern on the left was composed of more variable upper and lower units obtained by this method, whereas the poly-pattern on the

right was composed of units that are similar to each other. In the application on the right, the units constituting the poly-pattern have sharp lines which recall a mountainous surface, while the poly-pattern on the left is more curved and made from softer forms to represent bird feathers. In applications where positive and opaque planes were repeated in layers, the poly-patterns were developed in varying sizes and created from generative unit forms having straight-sharp or organic-soft characteristics.



Figure 5. The Poly-Patterns Produced by a Mountain Surface and Bluebird Feather as Bio-Patterns

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The studies in Figure 6 that were produced through the repetition of similar linear unit forms with changing heights transformed the microscopic images of a lizard's foot and gecko hair. These examples consist of straight and fractured linear forms, formed by cutting and folding cartons into strips. The homoge-

neous distribution, which the bio-patterns had, resulted in the linear elements forming the poly-patterns densely and homogeneously. The generative linear forms obtained by using the cardboard strips in the vertical direction repeat in decreasing / increasing dimensions to form a dynamic poly-pattern.

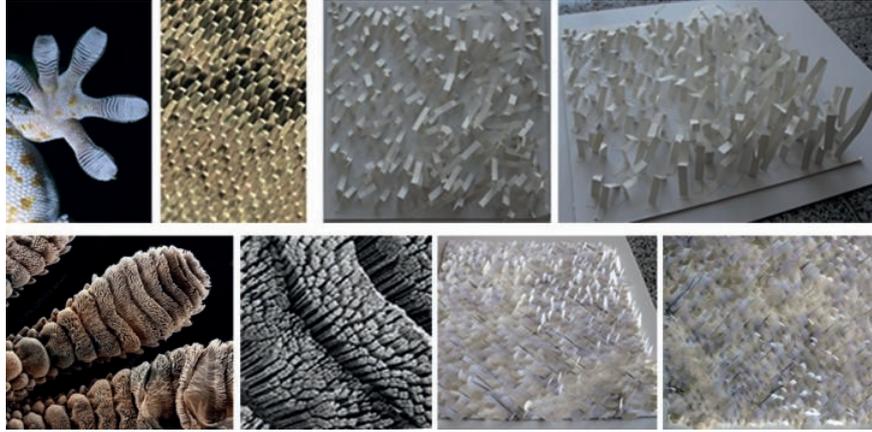


Figure 6. The Poly-Patterns Produced by the Microscopic Images of a Lizard's Foot and Gecko Hair as Bio-Patterns

RESULTS

In the evaluation of the questionnaire data derived from 50 participants, it was found that 92% of the students felt that the awareness of the design approaches, such as bio-design and bio-pattern, improved as a result of the seminars and studies on these topics, 6% of the students had no feelings about it, or were neutral, and 2% did not think that they had made progress on these topics. Regarding the second question on application of the design, 84% of

the students felt that the “generative units” provided them with knowledge of and experience in the contemporary design approach of generative design, which included the concept of repetitions, 16% of the students reported that they were neutral, and nobody had negative opinions on this topic. On the third question, 82% of the students agreed with the statement, “I think we have practiced a productive design with the similarity and repetition of the unit forms”, while 18% of the participants held a neutral view on this matter (Table 2).



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Table 2. The Questionnaire Data

QUESTIONNAIRE QUESTIONS (The responses to the Likert scale were derived from 50 students)	Certainly agree	Agree	Neutral	Disagree	Strongly disagree
The seminars and personal research on design approaches, such as bio-design and bio-pattern, have improved my awareness of this area.	4 (92%)	6	3 (6%)	1 (2%)	-
I was informed about and gained experience in generative design, which is composed of repetition of “generative units” and is one of the contemporary design approaches.	42 (84%)	-	8 (4%)	-	-
I think we have practiced a productive design with the similarity and repetition of the unit forms.	41 (82%)	-	9 (18%)	-	-
The study we performed through brain-hand coordination, instead of computer software, has contributed to my fine motor skills.	43 (86%)	-	6 (12%)	1 (2%)	-
I think we can develop a poly-pattern from a bio-pattern via generative design.	40 (80%)	-	9 (18%)	1 (2%)	-
This research provided me an opportunity to study inter-form relations, repetition-similarity and pattern issues related to each other, and to implement what I learned.	45 (90%)	-	2 (4%)	3 (6%)	-
Paper, cardboard (and acetate, if used) enriched my work with their different qualities (thickness, stiffness, elasticity, size, etc.) and prompted my creativity into action while creating patterns.	41 (82%)	-	5 (10%)	4 (8%)	-
The group work has developed my empathic approach, and the discussions have enriched the studying-learning process.	38 (76%)	-	8 (16%)	4 (8%)	-
The feedback I received from the course advisors and the actual discussion and inquiry environment supported the implementation and learning process.	46 (92%)	-	3 (6%)	1 (2%)	-
The study has provided a basis for the model and volume designs that we will implement in Basic Design 2 Studio. Designing through the model has contributed to improving my skills and confidence.	46 (92%)	-	3 (6%)	1 (2%)	-

The data showed that 86% of the students felt that the brain-hand coordination used in the design process, as opposed to using computer software, contributed to improving their fine motor skills, 12% were neutral about this topic and only 1 student did not agree. Regarding the



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question on the development of a poly-pattern from a bio-pattern using generative design, the data showed that 80% of the students felt that they could develop a poly-pattern out of a bio-pattern through generative design, 18% were neutral due to lack of self-confidence, and one student did not believe that it could be developed. While 90% of the students mentioned that the research enabled them to handle the issues of the relationships between forms, repetition-similarity and pattern and to implement the information that they learned, 4% of them indicated that they were neutral, and 6% felt that it did not contribute in this manner. A total of 82% of the students stated that paper and cardboard (and acetate, if used) enriched the work by means of different qualities (thickness, stiffness, flexibility, size, etc.) and allowed them to put their creativity into action, while 10% percent were neutral towards this topic, and 8% felt that the material did not make any contribution.

To continue, 76% percent of the students agreed with the statement that “The group work has developed my empathic approach, and discussions have enriched the studying-learning process”, 16% stated that they were neutral about this issue and 8% did not think that the research did this. The percentage of the students who agreed/certainly agreed that feedback from the studio advisors and the discussion and questioning environment

supported the implementation and learning process was 92%, whereas 6% indicated that they were neutral on this issue and 2% percent felt that the feedback did not contribute to the research. Lastly, 84% of the students agreed that the research was beneficial in terms of creating a basis for the design of model and volumes that would be addressed in the Basic Design Studio 2, improving their ability to make designs on the model and contributing to their self-confidence in this sense; there were no students that were in disagreement with this statement; and 16% stated that they were neutral about the contribution of the research in this manner (Table 2).

DISCUSSION

Biomimicry, as defined by Pawlyn in relation to architecture, is, in brief, the emulation of nature in developing architectural designs (Chiu and Chiou, 2009: 3636). Basic design studios provide transitions and relationships between concrete and abstract planes through the basic language of design and through cognitive thinking (Besgen et al., 2014: 429; Sarioğlu Erdoğan, 2016: 8-9) Basic design studios are practical settings for experiencing the relationship of biology and design. The results from the present research showed that the participation of the students in the basic design studio helped them to gain awareness through experience and to improve their research skills on the subject of biomimicry



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and the generative design method, which are fundamental to the design approach. In addition, the students achieved the targets of recognition/identification of different design process approaches, as determined by the Basic Design Studio 1 course offered by the Uludağ University Department of Architecture.

According to the questionnaire administered as part of this study, 80% of the participants felt that they could develop a poly-pattern out of a bio-pattern by using the generative design with repetition and similarity of unit forms; however, the observations made by the advisors and the quantitative evaluations made

by the jury suggest that this percentage was even higher, considering that 90% of the participants were successful in the poly-pattern development process. The lower percentage derived from the questionnaire can be attributed to the students' lack of confidence. In the process of generative design with repetition of similar unique forms, linear or planar forms are more dominated in different groups of examples in terms of production method, while volumes skillfully constitute the poly-patterns in the examples that are produced through the repetition of similar planes and transformation of the planes into volumes.

Table 3. Evaluation of the Outcomes in Terms of Production Method and Achievement Criteria

THE PRODUCTION METHOD of POLY-PATTERNS	A unique abstraction	Potential of the materials	Unique forms	Well- organized relations between forms and spaces	Contribution of different layers	Transition between scales
The repetition of similar planes and transformation of the planes into volumes by extending, stretching and heightening	√	√	Planes Volumes	√	√	√
Repetition and contrast of transparent and solid unit forms	√	√	Planes Linear f.	√	√	√
Repetition of similar straight linear or curvilinear planes	×	√	Linear f.	√	×	√
Repetition of similar folded planes with changing dimensions	√	√	Planes	√	√	√
Repetition of similar linear unit forms with changing heights	√	√	Linear f.	√	×	√



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The following outcomes can be stated when the effects of the methods followed for the production of poly-patterns are evaluated from the determined criteria in terms of the study purposes, as visualized in Table 3;

- The abstraction of the bio-patterns is unique in the process of creating the poly-patterns that are generated through the repetition of similar planes and transformation of these planes into volumes. The transformation of the planes into the volumes by extending, stretching and heightening them and the transition between different scales added variety and enriched these kinds of studies. Different layers and the potential of the materials contributed to the process with changing scales in these examples that are produced through well-organization of the changing scales, planes, volumes and the spaces between them.
- The unique abstraction of the bio-patterns through transparency and layers made the examples different from the other studies and enriched the poly-patterns which are produced through the repetition and contrast of transparent and solid unit forms. In the studies where the planar forms create spaces and the solid forms are designed as lines between them, the organization and transition of the forms, the spaces between them and the layers that

generate the poly-patterns are balanced. The usage of contrast, with the contribution of the materials, between the transparent and solid forms as a principle that support the repetition of unique forms intensified the poly-patterns.

- The potential of the materials contributed to the studies that are produced through the repetition of similar lines or planes by organizing the straight lines or curvilinear forms with changing heights, lengths and directions. The lines, planes and the spaces between them are well-organized in the transformation of poly-patterns from the bio-patterns although the abstraction is not sufficiently unique. Nevertheless, the poly-patterns are qualified in these studies in which a dense and homogeneous pattern consisted of lines and planes with the support of an intense workmanship in the production process.
- The poly-pattern examples that are produced by the repetition of similar folded planes or faulted surfaces with changing dimensions are abstracted through a unique approach. The potential of the materials contributed to these studies and enriched these examples in terms of abstraction, the organization of different dimensions, shapes and layers through folding. The folded planes that generate the whole characterize the poly-patterns



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by changing qualities, the relations between them and the transitions between changing scales of planar forms.

- The poly-patterns in the examples that are produced through the repetition of similar linear unit forms with changing heights are similar to each other in terms of their high density and homogeneous structure. It is positive that the poly-patterns are not monotonous and were abstracted through a unique approach in these studies that are made by focusing on dense and homogeneous areas of bio-patterns. The potential of the material contributed to the study through cutting and folding in terms of cutting, folding and multiplying the similar unique linear forms with the transition between different heights. The poly-patterns that are various in itself are generated through the homogeneous and dense repetition of the linear unique forms and transition between scales of linear forms and enriched with the intense workmanship in the production process.

The targeted acquisitions for the Basic Design studio 1 course offered by the Uludağ University Department of Architecture are to reflect design principles into the design during the process, to develop creative solutions and to think in a multi-dimensional/multi-purpose manner. The results acquired from the ques-

tionnaire data, the advisor observations and the jury evaluations showed that the students met the objectives of handling the relationships between forms, repetition-similarity and pattern issues and of implementing the learned issues. Therefore, the practice contributed, in terms of the department's stated general studio target acquisitions within the framework of two-dimensional basic design, to the students learning design principles/concepts, their implementation and their reflection on design by means of creative thinking. The students' works demonstrated that they were able to apply different concepts/principles in a comprehensive manner and reflect them onto design with a contemporary and innovative approach.

According to the work process, advisor observations and jury evaluations, the different qualities and limitations of the materials enriched the practice and triggered the students' creativity, and most of the students agreed that this was the case. It was expected that increasing the diversity of materials and giving the students the opportunity to get familiar with different materials would uniquely contribute to the students' research by facilitating their potential of generating custom products by the application. In this research, the focus was on pattern and transparency, leaving the color aside, to help trigger the creativity of students in the context of generating alterna-



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tive solutions. The products were developed within the framework of “pure design”, and all the products created by the students enriched the studio environment by presenting different poly-patterns consisting of similar materials. It was further observed that the different techniques used in determining the potential of the material for the work produced, from the form to the pattern, along with the transition between different scales, helped to develop the students’ creative thinking ability in all kinds of production methods, and the general studio course target acquisitions were supported by the material in this way. In addition to possibilities of the materials, experience with and observations in the process of product feasibility have shown that work performed by brain-hand coordination, rather than by computer software, contributes to improving fine motor skills. Almost 90% of the students supported this view. “Paper-fold” is a process exercise associated with basic coding, but nonetheless analogous to brain-hand coordination, as a computer-aided design and “low technology-high thinking” approach response to production (Vyzoviti, 2012: 10). The results of the experiment on the level of producibility according to “low technology-high thinking” in the first semester of the studio course have shown that generative design can be produced with the repetition of generative unit forms -without using software- in a qualified manner by using a hands-on

learning method. In addition, improvement in the fine motor skills of the students was also effective in strengthening the visual expression within the scope of general studio target acquisitions.

In the evaluations conducted on the practices carried out as group work, most of the students stated that the method helped them to adopt an empathic approach. The students felt that the discussions within the group enriched the study and the learning process. Based on the students’ experience and the advisor observations, it was determined that conducting the study in a collaborative, rather than in an individual way, has a positive effect, both in terms of the practice itself and in terms of preparation for the profession. As a result of the process, which puts forth the problem and generates solution alternatives for the students, who take on the role of “advisor” rather than “teacher”, almost all of the students argued that the feedback from the course advisors and the co-operative questioning and discussion environment supported the practicing and learning process. In this sense, as discussed in literature, the instructors as advisors focused on developing the students and their designs through their characteristics and tendencies, proceeded together with respect to combination of theoretical knowledge and production (Olivier and Tattersall, 2005: 30-31; Arıdağ and Koş, 2015: 104; Ünver, 2015:



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113). Design is an activity learned by sharing experiences with advisor(s) and experiencing the interaction environment between individuals (Schön, 1988: 5; Koper and Tattersall, 2005: 7). The group dynamics that emerge in the process, the feedback from the advisors, and the questioning and discussion environment all strongly contributed to the solution generation-implementation-learning process. In addition, the practice supported the ability to develop creative solutions to the problem with an open-minded and empathic approach, which was one of the studio's target acquisitions. At the end of the semester of Basic Design 1 studio, which is usually conducted through two-dimensional studies, the students' knowledge and know-how about design principles increased, and a specific knowledge infrastructure for design and the profession was formed. The poly-pattern work carried out involved a transition from two dimensional to three-dimensional study, and it created a basis for preparing the students for the Basic Design studio 2 course, which focuses on model making and volume designs. Where at first most of the students were "afraid" of making models due to their lack of self-confidence, after the practice, the students agreed with the idea that this study served as a basis for future studio works, improved their self-confidence and made them feel better prepared for the Basic Design 2 studio course; in addition, it contributed to

improving their ability to make and produce designs over the model. These acquisitions will serve to be quite beneficial for the students in dealing with the process of intense and varied design education in the first semester of their architecture studies.

The studio exercise required to integrate the information that is fragmentary taught and manipulate the form and information together in the formal evolution as discussed by Arıdağ and Koş (2015: 104) and Bekdaş and Yıldız (2018: 333). In this framework, it can be stated that the exercise that support the experimental learning as mentioned by Soliman (2017: 207), contributed to combine the information and practice for developing the achievement of connecting the parts as a whole.

CONCLUSION

The learning outcomes acquired in the Basic Design studio course, such as ability to identify the relations between forms, repetition-similarity, and pattern, are correlated with each other, as well as with the generative design approach, in terms of the process governing the transformation from bio-pattern to poly-pattern. The criteria for evaluating basic design studies aimed at production of poly-patterns by the abstraction and transformation of bio-patterns are the uniqueness, contribution of the materials, layers and scales and the



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quality of the organization. Some of these criteria are observed to be achieved in all of the studies such as utilizing the potential of the material, well-organization and transition between forms and scales, while some of them could be achieved in specific works such as creating different layers and diversifying the unique forms related to the production method.

The knowledge the students acquired, the awareness that they gained and the experience they acquired through the implementations are fundamental achievements that the course applied in this study. The issues that were addressed as part of the basic design studio curriculum were re-evaluated along with different innovative and contemporary approaches and transformed into an ultimate outcome, and the students' design education was supported through the experience-by-doing method. In the first semester of education, within the framework of "low technology-high thinking", it was observed that the generative design was able to be qualitatively performed via a hands-on approach, without using any software, with the aid of repetition of generative unit forms through creative methods. The study of the use of process-based poly-patterns in productive design and how to apply basic coding logic, transform works and patterns from 2D to 3D were beneficial in the sense of eliminating most of the

students' hesitation of creating a new model in studios, fostering self-confidence and giving the students the requisite skills to design through models. As a result, the process of learning was strengthened through the reciprocal feedbacks and interaction between the studio instructors and the students. The study which required integrating information, research and the implementation has contributed to experimental learning and connecting-combining different parts. Next phases of the study can be regarding new methods and exercises that focus on certain patterns, techniques or materials that can be determined according to tendencies of student group in order to develop their innovative and creative thinking.

REFERENCES

- ARIDAĞ, L., ERENGEZGIN, A., VURAL, T., (2000).** Mimarlık eğitiminde temel tasarım ve yaratıcılık, *Arkitekt*, 475:14-23
- ARIDAĞ, L., ASLAN, A., (2012).** Tasarım çalışmaları-1 stüdyosunda uygulanan yaratıcı drama etkinliklerinin mimarlık öğrencilerinin yaratıcı düşünce becerilerinin gelişimine etkisi, *Megaron*, 7(1):49-66
- ARIDAĞ, L., KOŞ, F., (2015).** Mimari tasarım stüdyosunda dinamik dizge



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www.mtddergisi.com

ULUSLARARASI HAKEMLİ TASARIM VE MİMARLIK DERGİSİ

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(Marka Patent No / Trademark)

(2015/04018 – 2015/GE/17595)

olarak mekanın yeniden üretimi: Alternatif plaj, Mimarist, 2015(3):101-105

BEKDAŞ, H.D., YILDIZ, S., (2018).

Tasarım ve sanat arakesitinde kavramsal düşünme: enformel eğitim çalışmaları, Megaron, 13(2):324-333. Doi: 10.5505/MEGARON.2018.26818

BENYUS, J.M., (1997). Biomimicry: Innovation Inspired by Nature. Harper Perennial, New York

BESGEN, A., KULOGLU, N., FATHALYZADEHALEMDARI, S., (2014). Teaching/Learning strategies through art: Art and basic design education, Procedia-Social and Behavioral Sciences, 182(2015):428-432. Doi: 10.1016/j.sbspro.2015.04.813

CHIU, W-T, CHIOU, S-C., (2009). Discussion on theories of bionic design, International Association of Societies Design Research Congress, Seoul, Korea, October 18–22, 2009:3625-3643

FINDELI, A., (2001). Rethinking design education for the 21st century: Theoretical, methodological, and ethical discussion, Design Issues, 17(1):5-17

GOKAYDIN, N., (1990). Eğitimde tasarım ve görsel algı. Ankara, Turkey: Sedir Yayınevi, ss. 38-39

KALAYCI, P.D., (2015). Mimarlığı eleştirmek: Bir yaklaşım önermesi. 1. Ankara, Turkey: Nobel Akademik Yayıncılık Eğitim Danışmanlık Tic. Ltd. Şti, ss.iii-vii,121-126

KOPER, R., TATTERSALL, C., (2005). Learning design: A handbook on nodelling and delivering networked education and training. Netherlands: Springer, ss.3-19

LIM, J., (2011). Bio-structural analogues in architecture. Netherlands: BIS Publishers, ss.12-14

MUELLER, T., (2008). Biomimetics: design by nature. National Geographic Magazine, April 2008, 213,4:68-92

OLIVIER, B., TATTERSALL, C., (2005). The learning design specification, A handbook on modelling and delivering networked education and training. Netherlands: Springer, ss.21-40

ONUR, D., ZORLU, T. (2017). Tasarım stüdyolarında uygulanan eğitim metotları ve yaratıcılık ilişkisi, The Turkish Online Journal of Design, Art and Communication, 7(4):542-555

ÖZEN YAVUZ, A., YILDIRIM, T., (2012). Utilization of digital-algorithmic design tools in architectural basic design education, Procedia - Social and Behavioral



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www.mtddergisi.com

ULUSLARARASI HAKEMLİ TASARIM VE MİMARLIK DERGİSİ

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(Marka Patent No / Trademark)

(2015/04018 – 2015/GE/17595)

- Sciences, 51:307-310. Doi: 10.1016/j.sbspro.2012.08.164
- ÖZGENCİL YILDIRIM, S., (2003).** Mimari tasarım sürecinin problematikleri, Ege Mimarlık, 47:35-40
- ROSHKO, T., (2010).** The pedagogy of bio-design: Methodology development, Conference: Design and Nature(2010):545-558, Volume:138. Doi: 10.2495/DN100491
- ROYALTY, A., (2018).** Design-based pedagogy: Investigating an emerging approach to teaching design to non-designers, Mechanism and Machine Theory, 125(2018):137-145. Doi: 10.1016/j.mechmachtheory.2017.12.014
- SAN, İ., (2008).** Sanat ve eğitim: Yaratıcılık, temel sanat kuramları, sanat eleştirisi yaklaşımları. Ankara, Turkey: Ütopya Yayınevi, ss.23-25
- SARIOĞLU ERDOĞDU, G.P., (2016).** Temel tasarım eğitimi: Bir ders planı örneği, Planlama 26(1):7-19. Doi: 10.5505/planlama.2016.52714
- SCHÖN, D.A., (1988).** Toward a marriage of artistry & applied science in the architectural design studio, Journal of Architectural Education, 41,4:4-10. Doi: 10.1080/10464883.1988.10758496
- SOLIMAN, A.M., (2017).** Appropriate teaching and learning strategies for the architectural design process in pedagogic design studios, Frontiers of Architectural Research, 6(2017):204-217. Doi: 10.1016/j.foar.2017.03.002
- ŞENEL, A., SÖNMEZ, N.O., (2017).** Bir derdimiz var! Mimarlık başlangıç stüdyosu, 1. Press, İstanbul, Turkey: Uniprint Basım San. Tic. A.Ş., ss.4-11
- TAVŞAN, C., TAVŞAN, F., SÖNMEZ, E., (2015).** Biomimicry in architectural design education, Procedia – Journal of Social and Behavioral Sciences, 182(2015):489–496
- TUNALI, İ., (2009).** Tasarım felsefesi. İstanbul, Turkey: Yapı Endüstri Merkezi Yayınları, ss.61-63
- ULUOĞLU, B., (2000).** Design knowledge communicated in studio critiques, Design Studies, 21(2000):33–58
- ULUSU URAZ, T., (1999).** Mimarlık bilgisi “eskizler” ve düşündükleri, Mimarlık,289:11-13
- USTA, G.K., ÖZDEMİR, İ.M., KULOĞLU, N., USTAÖMEROĞLU, A.A., BEŞGEN, A., VURAL, S., (2000).** Mimarlık eğitiminde temel tasarımın yeri, Mimarlık, 293:41-44



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ULUSLARARASI HAKEMLİ TASARIM VE MİMARLIK DERGİSİ

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(Marka Patent No / Trademark)

(2015/04018 – 2015/GE/17595)

UYSAL, V.F., ARIDAĞ, L., (2012). “Perform-box”: Towards an architecture-of-time, Performance Research, 17(5):119-129. Doi: 10.1080/13528165.2012.728452

ÜNVER, E., (2015). Sanatın ve sanateğitiminin değer oluşturmada yeri ve önemi, International Refereed Journal Of Design and Architecture 04(02)Spring:111-120. Doi: 10.17365/TMD.201549617

VYZOVITI, S., (2012). Supersurfaces: Folding as a method for generating forms for architecture, products and fashion. Netherlands: BIS Publishers, ss.6-10

YÜREKLİ, H., YÜREKLİ, F., (2004). Mimarlık: Bir entelektüel enerji alanı, İstanbul, Turkey: Yapı Endüstri Merkezi Yayınları, ss. 9-24

ZARI, M.P., (2007). Biomimetic approaches to architectural design for increased sustainability. Paper no: 033, presented at (SB07) Regional Sustainable Building Conference, Auckland, New Zealand (page number does not exist)

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<http://www.arkitera.com/haber/19038/mimaride-biyomimikri> (E.T. 01.11.2018)