UTM UNIVERSITI TEKNOLOGI MALAYSIA

IJBES

International Journal of Built Environment and Sustainability
Published by Penerbit UTM Press, Universiti Teknologi Malaysia
IJBES IJBES 12(1)/2025,1-8

Landscape Design as Art: An Experimental Methodology with the Use of Neurographic Art and Metaball Geometry

Asli Agirbas
Department of Architecture, Ozyegin University, Istanbul, Turkey
asliagirbas@gmail.com

Roza Sabyrova ,Tarik Emre Kirhalli
Department of Architecture, Ozyegin University, Istanbul, Turkey

ABSTRACT

With the use of new technological solutions, non-Euclidean forms can be created in various software platforms and can be produced or fabricated in order to be parts of real world design works. Therefore, new methodology proposals for creation of non-Euclidean forms can be helpful to both designers and design students. In this study, an experimental landscape design methodology which is carried out within the scope of Ozyegin University, Department of Architecture, Architectural Design Studio V and Parametric Design courses, is presented and discussed. Neurographic art is used as a manual art case and metaball script is used as a digital art case of this method. This method has been evaluated and discussed from the perspective of the educators and students. As a result, it has been concluded that the proposed landscape design methodology can be used for the creation of non-Euclidean landscape design forms.

Article History

Received : *8 October 2023*
Received in revised form : *21 August 2024*
Accepted : *5 September 2024*
Published Online : *10 January 2025*

Keywords:

Neurographic art, Metaball, Parametric design, Landscape design, Design education.

Corresponding Author Contact:
asliagirbas@gmail.com

DOI: 10.11113/ijbes.v12.n1.1214

1. Introduction

The creation of landscape design related to the building form is another concern of designing buildings with complex forms. On the basis of form, building design and landscape design are not always expected to be related. However, with the help of the new technologies, buildings of very different complexity can now be produced. Therefore, non-Euclidean building forms integrated with the landscape design can be created. In this research, an experimental study was carried out for the landscape design with the complex form developed within the scope of architectural design studio course and parametric design course. Neurographic art, which is also known as an art therapy method, was used for manual art case. Metaball creation through parametric design tool was used for the digital art case.

Neurographics, which was proposed by a Russian psychologist Pavel Piskarev in 2014, combines graphic imaging techniques with psychological approaches (Uchkunovna Rakhmanova, 2023). Similar to the other art therapy methods, neurography is based on analytical psychology, gestalt psychology, neuropsychology and psychosynthesis (Chushikina and Vinarchik, 2020). In the manual art case section of this study, it is suggested to use neurographic art while creating landscape design as a methodology. Similar

studies based on the use of art in design are also available in the literature. Al-Deen Mohammad and Alabdulla (2022), as an example, asked landscape design students to search for a modern artist, to create their own art drawings by examining this artist's art principles (such as form, pattern, composition), then to use these art drawings as an inspiration and to consider them as the basic concept of their designs. Students adopted form-based design approach as a basis while carrying out this work (Fillippi and Barattin, 2015). Yavuz (2014) also applied a similar methodology with landscape architecture students. Kılıçaslan and Kuloglu (2015) used the method of transforming art pieces of Mondrian and Von Ebneth to the third dimension for architectural design process as well. Furthermore, in the studies of Caner Yüksel and Dinç Uyaroğlu (2021), Hatıpoğlu et. al. (2022) and Hatıpoğlu et. al. (2023), body movements are transformed into form as a design methodology which can be grouped under a similar category.

In the digital art case of this study, the creation of metaball geometry through parametric design tool was adopted. Fluid-looking forms can be created with metaball scripts of parametric design tools (Agirbas, 2022). Parametric design tools provide a platform for easily refining designs in the digital environment where shape boundaries can be flexible through the written codes. This situation pushes the designer to constantly rethink within the scope of the form-aesthetic relationship. Shape parametrization process is similar to the sketching process. Therefore, parametric design tools can be used in a similar manner to create forms in the sketching process (Agirbas, 2017). There are also many studies to make these tools as a part of design education. The studies of Vrouwe et.al. (2020), Abdelmohsen and Massoud (2021), Gallas et. al. (2015), Celani and Verzola Vaz (2012), Aish and Hanna (2017), Agirbas (2015) and Agirbas (2023) can be given as an example to this. In addition to the integration of parametric design tools into design education, the integration of CAD tools into design education has been a topic of interest for a long time, as in the cases of Al-Qawasmi (2005), Çolakoğlu and Yazar (2007), Achten (2003), Soliman et. al. (2019), Fricker et. al. (2020) and Youssef (2023). The use of computer simulations for both environmental design and its assessment (of its aesthetic qualities, aesthetic value in the eyes of its observers, acoustic performance, ageing process etc.) as seen and discussed in the works of Fan (2022), Yang (2021), Irvine et. al. (2021) and Jeon and Hong (2015) can be highlighted as another approach.

2. Manual Art Case: The Landscape Design Methodology with Neurographics

Circles, triangles, squares, and special curved lines, similar to the neural connections in our brain are used in neurographic art. Basically, the lines are drawn, then intersections and shapes are created. The colors are used freely. However, working with colors also has its own principles, such as the use of a single color for a specific pattern in order not to create obvious shapes. Various lines are used at every stage of the movement in the pattern. Trajectory should not be straightforward and oscillation frequency should be unique. To draw a picture, a sheet of paper of any format is sufficient, along with pencil, felt-tip pen, or liner, with which lines and shapes can be created.

In the architectural design studio V Project of Spring 2023 semester, the aim was to design a natural science museum, where this experimental study was conducted with 1 student. In order to blend the architectural form with landscape design, neurographic art was used as a layout. As can be seen in the Figure 1, many neurographic art drawings have been made beforehand. The sample, which is thought to be related to the form of the building design, was chosen for application. Then, the art sample has been scaled accordingly (Figure 2). As a result, the curved red long lines in the drawing turned into the paths in the landscape design (Figure 3).

The student's project covers the design of the buildings as well as the surrounding landscape. The complex has five buildings with curvilinear forms, each possessing different functions. Three buildings serve as exhibition halls, where the visitors can examine current and historical specimens. Since the project area is next to Istanbul University and its dormitory, the building complex also includes a library and a cafe.

3. Digital Art Case: The Landscape Design Methodology with the Use of Metaball Script

Rhino and Grasshopper software are taught within the scope of the Parametric Design elective course where the experimental study was carried out. In Rhino, 2D drawing techniques were first shown, and then commands for 3D modeling were shown. After teaching 3D modeling in Rhino, basic commands in Grasshopper were taught in the course. After teaching the operation of Grasshopper and the creation of basic geometric components, specific components were discussed. The course focuses specifically on the use of components that include the production of Voronoi, Metaball and Delaunay Triangulation forms. Thus, students learn about how complex forms can be easily produced in Grasshopper. The course is 2 hours per week. During the period when this study was conducted (Spring 2023), 4 second-year architecture students were enrolled in the course. In one week of this course, 'parametric landscape design' experiments, which are the subject of this study, were carried out. Metaball script was used during these experiments. Students produced various forms by playing with the number sliders of various components in the script and tried to interpret these forms as landscape designs.

Ready-made Metaball component was used in the script (Agirbas, 2022). Random points were created by connecting the 'populate 2D' component to the point input of the Metaball component. The form can be parametrized by changing the number of points with the help of the number slider. The 'Seed' input can also be controlled with the help of the number slider, and the points can be created in different locations with each different number input. Different forms can be obtained by playing with the script's number sliders. After the pattern was created, the desired loop-shaped lines were turned into surfaces with the 'Planarsrf' command in Rhino. The surfaced parts can be set in different layers and given various colors. Thus, landscape design drafts were created.

At the end of the course, a survey was conducted in which students could participate voluntarily. 3 out of 4 students taking the course participated in this survey. The questions in the survey are listed in Table 1. With these questions, an idea about the students' views on 'parametric landscape design' experiments and information was obtained. Similar answers were received from the students to the first question about the applicability of the experimental 'parametric landscape design' study (Table 2). According to the answers, the method is applicable. While one student answered 'no idea' to the second question about producing new design alternatives while parameterizing, the other 2 students think that new design alternatives can be produced while parameterizing. 2 students agree on the similarity between parametrization and manual sketching, which is discussed in the third question, but 1 student thinks that parametrization and manual sketching are not similar. According to the answers to the fourth question, every student agrees that they can apply this type of experimental methods in their future projects. Although one student selected the 'no idea' option regarding the ability to easily produce complex forms discussed in the fifth question, the other 2 students think that they can apply complex forms in design projects. The sixth question is about the use of ready-made scripts in form production. Accordingly, all 3 students think that ready-made scripts can be easily used in form production. Since the number of people taking elective courses is very low, the number of students answering the survey is also very low. However, it still sheds light on understanding students' ideas on the subject.

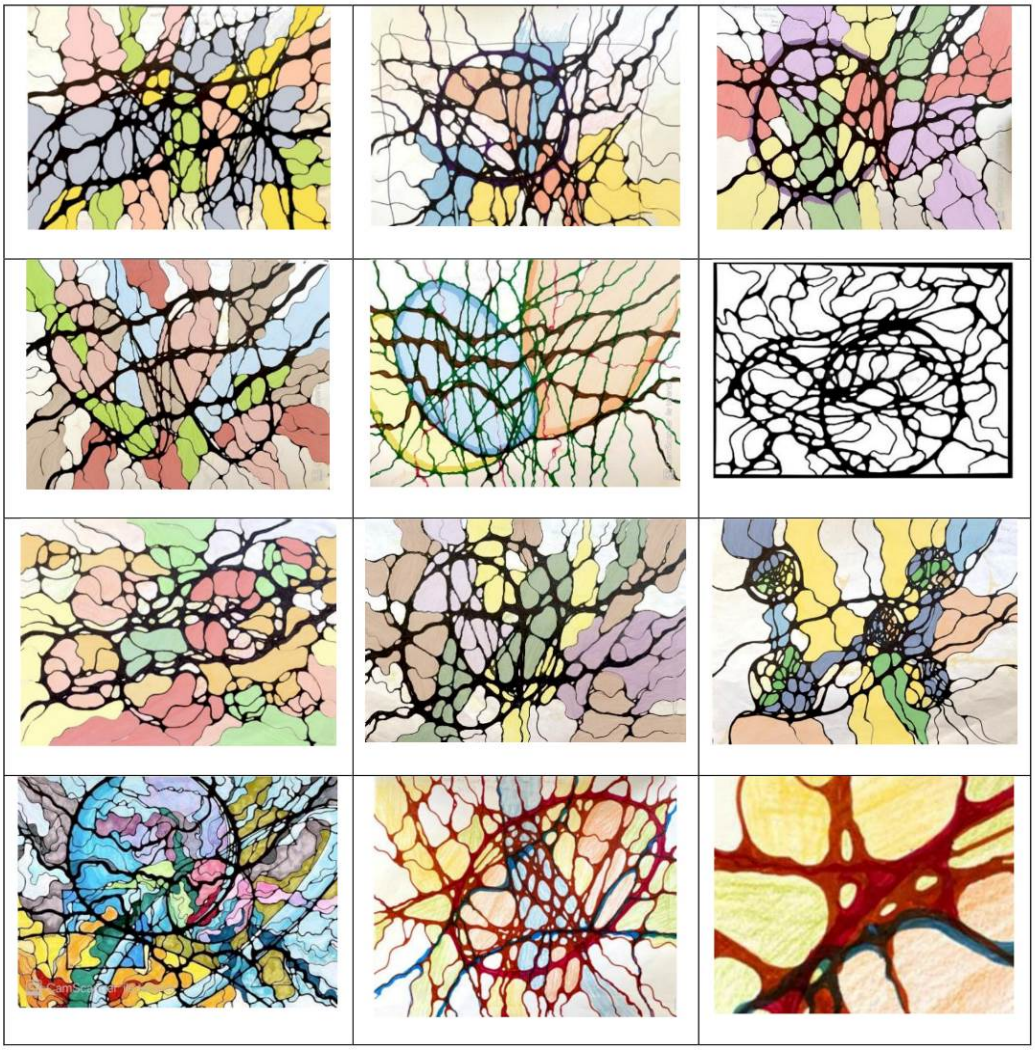

Figure 1. Studies within the scope of neurographic art (Image by Roza Sabyrova)

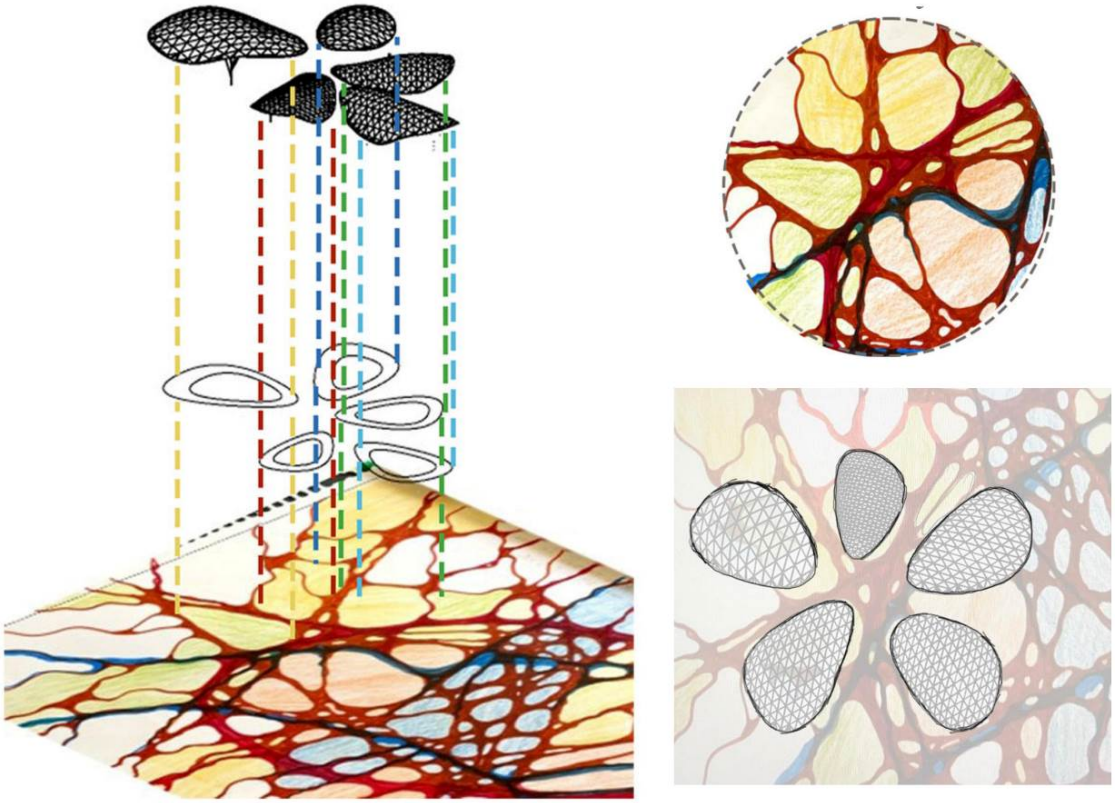

Figure 2. Matching building forms with neurographic art image (Image by Roza Sabyrova)

Figure 3. An image from the work produced within the scope of Architectural Design Studio course (Image by Roza Sabyrova)

4. Evaluation of the Method from the Perspective of the Educator

During the landscape design process, especially if the architectural design project includes non-Euclidean forms, students start to search for a reference for form creation. An art approach like the one in this study can actually be used as a reference for landscape design. This reference art layout includes basic design principles (symmetry, proportion, centrality, balance etc.) which in turn help students to make design decisions. It can also be a source of inspiration for landscape layout as it contains various forms. These forms can represent different elements of a landscape design such as green and pavement areas. In addition, colors can be an inspiration parameter for the students. This process is similar to iterative sketching process (Goel, 1995; Goldschmidt and Smolkov, 2006; Schon and Wiggins, 1992) which helps designer to refine their ideas. This iterative process in sketching is always considered as a tool in design studies. A similar perspective is found in the studies of Schütze et. al. (2003), Kelley and Sung (2017), Hua (2019), Yorgancıoğlu and Genel (2021).

In artistic image production, the student can reveal the basic design principles (Hsieh et. al. 2022) unintentionally. In these visual productions, features such as symmetry, balance, harmony, order and ratio appear indirectly. It is the specific combinations of these features that create pleasurable emotions related to the artistic creation in question (Çınar and Erdönmez, 2008). When we consider landscape design as a form-oriented process, there are approaches that focus on aesthetic concern in landscape form creation such as designs of Roberto Burle Marx (Iris Montero, 2001; Doherty, 2018). The aesthetic values generated by such designs, along with their effects on human perception can, in turn, be identified, evaluated and measured by using various parameters to further increase the uniqueness, attractiveness and aesthetic valences of urban spaces as discussed by Gheorghiţă and Grigorovschi (2012) and Bibaeva (2022). The artistic images that emerge as a result of the expression of the student's talents can also be integrated into the processes of creating such landscape designs. Landscape designs can be adapted to the artistic images by adjusting the scale. Landscape objectives can also be handled simultaneously during artistic image creation. Although the direct integration of artistic image as a pedagogical methodology into the landscape design is a more straightforward approach, it can be interpreted as a mechanism that creates more surprises and leads the student to rethink and revise. In this process, literally, the artistic image itself guides the student. Since the layout has been created, the student will begin to examine and reinterpret this layout. For example, the circles may remind the student that there may be green areas, or the student may think that the curved line may be a pathway.

Besides the positive and thought-forming aspects of this method, there are of course also negative aspects. The neglection of the third dimension by the student can be considered as one of those aspects. For students who may face difficulties in understanding the management and arrangement of topography, this method may inevitably make this management more difficult. Therefore, it would be more meaningful to apply this method on flat areas, or motivate the students with necessary skills for its use. The data in the artistic image can be directed to the third dimension (in relation to topography). An additional problem, which will arise from the creation of landscape design as a pattern-study can be the detachment from its context. Below, a few of these issues are listed:

- The random/hit-or-miss relationship between the created landscape and the existing urban tissue, which relates to the aforementioned problem of the relationship with the third dimension and topography,
- The functional considerations and problems of the created landscape (e.g. successful articulation to the existing paths; the compatibility of the newly added paths with the existing functions; proper consideration of the shapes of these paths and their material selection with weathering and environmental conditions in mind (Çınar and Erdönmez, 2008); the logical placement of architectural elements; proper adaptaiton to the pedestrian circulation habits and patterns),
- Difficulties in determining and arranging the thresholds of the pattern (the problem of whether the area considered for landscape design will be sufficient when it is considered as a transition element between the geometry of the urban context and the architectural elements).

All these topics show that the success of this method lies in the student's proficiency in spatial design along with her/his artistic ability.

The production of multiple artistic images can actually be associated with the production of design alternatives, and should be further encouraged throughout the process. This situation is similar to creating variations with parametric design tools. As a matter of fact, when using parametric design tools, we can change the values of various parameters and produce new variations formally.

The process of parameterization using algorithmic tools reveals surprising forms and leads to a completely new area in terms of aesthetic evaluation and judgment of the resulting form/object/space. Although this situation is different from manual drawing, the situations intersect at some points. In manual drawing, differences or randomness in the tools used create similar situations. As one of the best examples of this situation, we can give Jackson Pollock paintings that integrate with the concept of emergence. Pollock was creating layered paintings with movement in different directions (Rosi et. al. 2016). Algorithmic tools help us experience a similar process. Another difference in designs made using algorithmic tools is the go-back option. If the user does not like the move made, he or she can easily undo or change the variable.

Table 1. Questionnaire about the 'parametric landscape design' experiment

Question number	Question
1	I think the experimental 'parametric landscape design' method used in this study may be a landscape design method.
2	Parametric changes made with Number Slider component help me generate new design alternatives/ideas.
3	The parameterization method made with the Number Slider component is similar to manual sketching.
4	I consider applying similar methods in my future projects.
5	I think I can easily produce complex forms in my design projects.
6	Using various ready-made methods in developing forms in a computer programme can make my job easier.

Table 2. Students' perspective

No	1 (Strongly disagree)	2 (Disagree)	3 (No idea)	4 (Agree)	5 (Strongly agree)
1	-	-	-	2	1
2	-	-	1	1	1
3	-	1	-	1	1
4	-	-	-	2	1
5	-	-	1	1	1
6	-	-	-	2	1

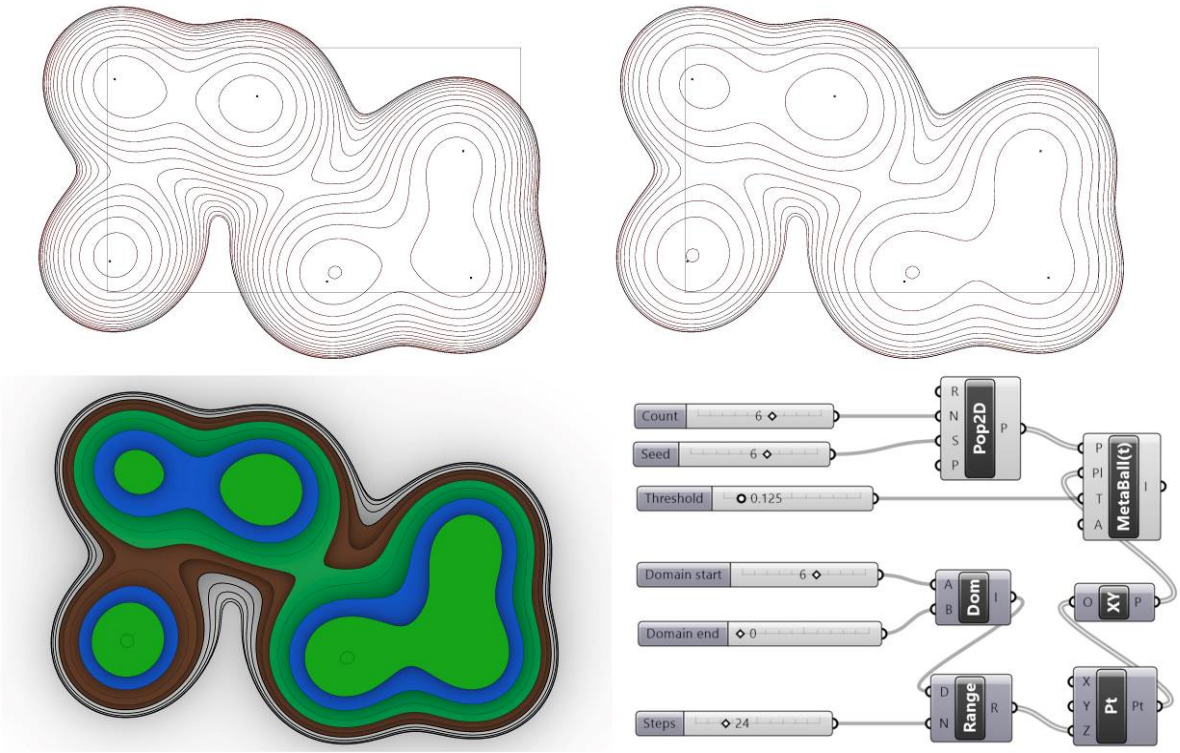

Figure 4. Landscape design draft example produced with the use of Metaball script.

5. Conclusion

With the help of new technologies, complex form productions came to the fore. This situation leads designers to search for alternative forms which are possible to produce now. Accordingly, new design methodologies for the creation of these alternative forms are being searched both in the sector and in the academia. In this study, an experimental methodology has been used for the creation of landscape design within the scope of Architectural Design Studio and Parametric Design courses. The methodology is based on the use of neurographic art and Metaball script for landscape design. The results show that this methodology can be used for the creation of landscape design with non-Euclidean forms, but requires a certain level of talent from its user. Considering the user's talent, which effect or will effect the design, it is obvious that this requirement will increase as the design becomes more complex.

The use of art as a design method, directly or indirectly, has been around for many years. We see that art is used as a source of inspiration in design using various methods. However, today, the way of handling the art is also changing and developing. Classical art is being replaced by digital art, and a wide variety of production methods are emerging. In this case, the ways, in which art can be a source of inspiration for design, will expand and different possibilities will emerge.

Although this study was done in landscape design, it can also be used in other design fields. The use of such various design guiding methods in education will help students learn about the diversity of design methods. In particular, the application of digital and hybrid experimental methods is important for students to see in what forms the tools can be utilized. Such experimental methods will broaden students' horizons in using the tools.

This study was conducted on a small group. For a broader discussion, a survey can be conducted on a similar topic with larger groups as a future study. Furthermore, a quantitative evaluation of landscape design performance metrics (such as cost, applicability etc.) could provide valuable insights into the practical implications of the proposed methodology.

Acknowledgements

We would like to thank the reviewers for their valuable suggestions

References

Abdelmohsen, Sherif and Massoud, Passaint (2021), 'A material-based computation framework for parametric design education', *Open House International*, 46:3, pp. 459-475. https://doi.org/10.1108/OHI-02-2021-0043

Achten, Henri H. (2003), 'New Design Methods for Computer Aided Architectural Design Methodology Teaching', *International Journal of Architectural Computing*, 1:1, pp. 72-91. https://doi.org/10.1260/147807703322467441

Al-Deen Mohammad, Omar Hosam and Alabdulla, Montasir Masoud (2022), 'Landscape architecture design as an art creative practice: A studio teaching model', *Landscape Architecture and Art*, *20:*20, pp. 92–101. https://doi.org/10.22616/j.landarchart.2022.20.10

Al-Qawasmi, Jamal (2005), 'Digital media in architectural design education: Reflections on the e-studio pedagogy', *Art, Design & Communication in Higher Education*, 4:3, pp. 205- 222. https://doi.org/10.1386/adch.4.3.205/1

Aish, Robert and Hanna, Sean (2017), 'Comparative evaluation of parametric design systems for teaching design computation', *Design Studies,* 52, pp. 144–172. https://doi.org/10.1016/j.destud.2017.05.002

Agirbas, Asli (2023), 'A methodology for 3D digital sketching practise in undergraduate architectural education', *Art, Design & Communication in Higher Education,* 22 (2), 171 - 185. https://doi.org/10.1386/adch_00073_1

Agirbas, Asli (2022), 'A Teaching Methodology on the Combination of Architectural Tradition and Parametric Design: A Case Study with Birdhouses', *International Journal of Islamic Architecture*, 11 (1), pp. 149-168. https://doi.org/10.1386/ijia_00068_1

Agirbas, Asli (2017), 'The Use of Simulation for Creating Folding Structures: A Teaching Model', in *Proceedings of the 35th eCAADe Conference*, Sapienza University of Rome, Rome, Italy, 20-22 September, pp. 325-332. https://doi.org/10.52842/conf.ecaade.2017.1.325

Agirbas, Asli (2015), 'The Use of Digital Fabrication as a Sketching Tool in the Architectural Design Process: A Case Study', in *Proceedings of the 33rd eCAADe Conference*, Vienna University of Technology, Vienna, Austria, 16-18 September, pp. 319-324. https://doi.org/10.52842/conf.ecaade.2015.2.319

Bibaeva, A. Yu. (2022), 'Aesthetic Assessment of Landscapes at the Regional Level (a Case Study of the Central Ecological Zone of the Baikal Natural Territory)', *Geography and Natural Resources*, 43:2, pp. 182-188.

Celani, Gabriela and Vaz, Carlos Eduardo Verzola (2012), 'CAD Scripting and Visual Programming Languages for Implementing Computational Design Concepts: A Comparison From A Pedagogical Point Of View', *International Journal of Architectural Computing,* 10:1, pp. 121–137. https://doi.org/10.1260/1478-0771.10.1.121

Caner Yüksel, Çağla and Dinç Uyaroğlu, İlkay (2021), 'Experiential Learning in Basic Design Studio: Body, Space and the Design Process', *International Journal of Art Design Education*, 40, pp. 508-525. https://doi.org/10.1111/jade.12364

Chushikina, Kate and Vinarchik, Elena (2020), 'Neurography as a way to deal with stressful situations in learning', *Inovace a technolohie ve vzdelavani, 1,* pp. 50-53.

Çınar, H. Sanem and Erdönmez, Müge Özgüç (2008), 'Peyzaj Tasarımında Biçim Geometrisine Estetik Bir Yaklaşım', *İstanbul Üniversitesi Orman Fakültesi Dergisi*, 58:2, pp. 23-40.

Çolakoğlu, Birgül and Yazar, Tuğrul (2007), 'An Innovative Design Education Approach: Computational Design Teaching For Architecture', *METU JFA*, 24:2, pp. 159-168.

Doherty, Gareth (2018), *Roberto Burle Marx Lectures; Landscape as Art and Urbanism*, Zürich, Switzerland: Lars Müller Publishers.

Fan, Jing (2022), 'Ageing Design of Urban Park Landscape Based on Computer Virtual Simulation Technology', *Computational Intelligence and Neuroscience*, Vol. 2022, pp. 1-9. https://doi.org/10.1155/2022/3150371

Filippi, Stefano and Barattin, Daniela (2015), 'Definition of the form-based design approach and description of it using the FBS framework', in *The 20th International Conference on Engineering Design (ICED15),* Politecnico di Milano, 27-30 July, Milan.

Fricker, Pia, Kotnik, Toni and Borg, Kane (2020), 'Computational Design Pedagogy for the Cognitive Age', in *Proceedings of eCAADe Conference*, TU Berlin, Berlin, Germany, 16-18 September 2020, pp. 685-692. https://doi.org/10.52842/conf.ecaade.2020.1.685

Gallas Mohamed-Anis, Jacquot Kevin, Jancart Sylvie and Delvaux Frédéric. (2015), 'Parametric Modeling: An Advanced Design Process for Architectural Education', in *Proceedings of eCAADe Conference*, Vienna University of Technology, Vienna, Austria, 16-18 September, pp. 149-157. https://doi.org/10.52842/conf.ecaade.2015.2.149

Gheorghiţă, Constanţa Carmina and Grigorovschi, Mircea (2012), 'The Aesthetic Values of Landscape Design', *Bulletin of the University of Agricultural Sciences & Veterinary Medicine Cluj-Napoca. Horticulture*, 69:1, pp. 152-160.

Goel, Vinod (1995), *Sketches of thought,* Cambridge, MA: MIT Press.

Goldschmidt, Gabriela and Smolkov, Maria. (2006), 'Variances in the impact of visual stimuli on design problem solving performance', *Design Studies*, 27:5, pp. 549-569. https://doi.org/10.1016/j.destud.2006.01.002

Hatıpoğlu, Serkan Can, Şensoy, Gamze, Kamaoğlu, Melih and İnceoğlu, Mehmet. (2022), 'Initial Practices for Abstraction of Body

and Space in Design Education', *Online Journal of Art and Design*, 10:2, pp. 282-298.

Hatıpoğlu, Serkan Can, Kamaoğlu, Melih, Şensoy, Gamze and İnceoğlu, Mehmet (2023), 'Body, dance and abstraction for spatial and structural comprehension in the first year of design education', *International Journal of Technology and Design Education*. https://doi.org/10.1007/s10798-023-09821-1

Hsieh, Ying-Yi, Chen, Chun-Ching and Chen, Wen-Yin (2022), 'Form Development from 2D to 3D: The Basic Design Courses for Higher Education', *International Journal of Art & Design Education*, 41, pp. 96-107. https://doi.org/10.1111/jade.12377

Hua, Min (2019), 'The Roles of Sketching in Supporting Creative Design', *The Design Journal,* 22:6, pp. 895-904, https://doi.org/10.1080/14606925.2019.1655187

Iris Montero, Marta (2001), *Roberto Burle Marx: The Lyrical Landscape*, Berkeley and Los Angeles: University of California Press.

Irvine, Kim N., Loc, Ho Huu, Sovann, Chansopheaktra, Suwanarit, Asan, Likitswat, Fa, Jindal, Ranjna, Koottatep, Thammarat, Gaut, Jarrod, Chua, Lloyd H. C., Qi, Lai Wen, Wandeler, Koen De (2021), 'Bridging the form and function gap in urban Green space design through environmental systems modeling', *Journal of Water Management Modeling*, 29:C476, pp. 1-19. https://www.chijournal.org/C476

Jeon, Jin Yong and Hong, Joo Young (2015), 'Classification of urban park soundscapes through perceptions of the acoustical environments', *Landscape and urban planning*, 141, pp. 100-111. https://doi.org/10.1016/j.landurbplan.2015.05.005

Kelley, Todd R., Sung, Euisuk (2017), 'Sketching by design: teaching sketching to young learners', *International Journal of Technology and Design Education,* 27, pp. 363–386. https://doi.org/10.1007/s10798-016-9354-3

Kılıçaslan, Hare and Kuloglu, Nilgün. (2015), 'Visual Literacy during the Period of Architectural Education', *Procedia - Social and Behavioral Sciences*, 191, pp. 2824-2828, https://doi.org/10.1016/j.sbspro.2015.04.711

Rosi, F., Grazia, C., Fontana, R., Gabrieli, F., Pensabene Buemi, L., Pampaloni, E., Romani, A., Stringari, C. and Miliani, C. (2016), 'Disclosing Jackson Pollock's palette in Alchemy (1947) by non-invasive spectroscopies', *Heritage Science*, 4, 18. https://doi.org/10.1186/s40494-016-0089-y

Schon, Donald A. and Wiggins, Glenn (1992), 'Kinds of seeing and their functions in designing', *Design Studies,* 13:2, pp. 135–156. https://doi.org/10.1016/0142-694X(92)90268-F

Schütze, Martina, Sachse, Pierre and Römer, Anne (2003), 'Support value of sketching in the design process', *Research in Engineering Design*, 14, pp. 89–97 https://doi.org/10.1007/s00163-002-0028-7

Soliman, Sara, Taha, Dina, El Sayad, Zeyad (2019), 'Architectural education in the digital age: Computer applications: Between academia and practice', *Alexandria Engineering Journal*, 58:2, pp. 809-818. https://doi.org/10.1016/j.aej.2019.05.016

Uchkunovna Rakhmanova, Dilfuza (2023), 'The role of Neurography in Art Therapy', *International Scientific Journal*, 12:3, pp. 73- 76.

Vrouwe, Ivo, Dissaux, Thomas, Jancart, Sylvie and Stals, Adeline. (2020), 'Concept Learning Through Parametric Design: A learning situation design for parametric design in architectural studio education', in *Proceedings of eCAADe Conference*, TU Berlin, Berlin, Germany, 16-18 September 2020, pp. 135-144. https://doi.org/10.52842/conf.ecaade.2020.2.135

Yang, Le (2021), 'Computer simulation of urban garden landscapedesign based on FPGA and neural network', *Microprocessors and Microsystems*, 83, 103988. https://doi.org/10.1016/j.micpro.2021.103988

Yavuz, Aysel (2014), 'As An Approach to Improving Creativity in Design Education; Art of Painting', *Procedia - Social and Behavioral Sciences*, 141, pp. 741 – 747.

Yorgancıoğlu, Derya and Genel, Özlem Altınkaya (2021), 'Reversing the design process in the introductory architectural design studio: The exploratory function of sketch modelling', *Art, Design & Communication in Higher Education*, 21:1, pp. 67 – 84. https://doi.org/10.1386/adch_00047_1

Youssef, Amr Mamdoh Ali (2023), 'A Proposed Guide for Promoting Educational and Learning Techniques of CAAD', *Fayoum University Journal of Engineering*, 6:1, pp. 20-38. https://doi.org/10.21608/fuje.2022.168181.1024