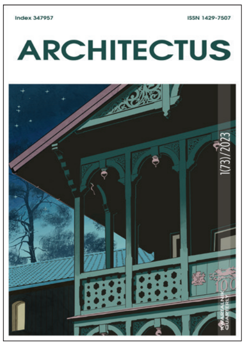

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A parametric design offering affordances for the children of digital world: playground inspired by Voronoi

Introduction

Recent studies show that access to nature and green spaces is beneficial to physical, emotional and cognitive health, such as reducing the risk of childhood obesity, reducing aggression and stress levels, increasing academic performance and enhancing the ability to concentrate [1]–[5]. From this point of view, as research on the importance of outdoor play has increased, concerns have grown about the long-term consequences of reducing children's contact with nature. In the United States, where these concerns are emerging, a nationwide "leave no child inside" movement has been launched [6], [7].

Children learn about themselves, their peers, and their environment through play. Through play they establish relationship with their physical environment. *Play is how a child discovers his relationship to the world. The act of playing should hardly be limited by the environment in which the playing occurs: the playground* [8, p. 18]. The role of the playground is to motivate the child to play creatively within its space. A playground that gives the child too much guidance discounts his ability to take initiative and act out of a creative response to curiosity.

As the country industrialized, children were taken off the streets and formalized urban play environments were born. However, as Paul Friedberg and Ellen Perry Berkeley note, the street, "spontaneous, exciting and immediate" easily wins a child's affection as an ideal landscape for play [8, p. 21]. If it were not for the safety factor, there would be no reason to dissuade a child from playing on the street. Of course, safety is an issue, so children are asked to play within the boundaries of the playground. However, this preferred play environment, the playground, does no favor to the child by limiting his or her options.

Another major problem that is separating today's children from outdoor play is the digital world. There is a growing discrepancy between the time children spend indoors, connected to technology, and the time they spend outside enjoying nature. Most today's children use the computer, watch TV or play video games every day, but only about 10 percent say they spend time outdoors every day, according to a new nationwide survey by The Nature Conservancy. According to Marc Prensky [9], who first mentioned it in the academic world and coined the term "digital natives" today's students represent the first generations to grow up with this new technology. They have spent their entire lives surrounded by and using computers, video games, digital music players, video cameras, cell phones, and all the other toys and tools of the digital age. Today's average college graduates have spent less than 5,000 hours of their lives reading, but over 10,000 hours playing video games (not to mention 20,000 hours watching TV). Computer games, email, the Internet, cell phones and instant messaging are integral part of their lives. Therefore, to bring children back to outdoor play, playground designers should create engaging and attractive play experiences for them. In fact, traditional playgrounds do not meet the needs of today's children, as we now have a new generation with a very different mix of cognitive skills than its predecessors – Digital Natives.

Inspiration for designed forms can come from many sources. Easily "nature" may be the only source of inspiration one will ever need. While it is admirable to understand the processes and patterns of nature and use them as a source of inspiration, copying nature directly denigrates

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the original form. One can imitate the logic of nature and draw inspiration from its forms, but copying it directly does a disservice to the profession and demeans the form from which it originated.

As explained in the scope of the research, "can a biomorphic approach provide a perspective in playground design that will encourage the children of this age to play outdoors and offer new and creative play opportunities according to their diverse expectations and abilities?" This question was the motivation for the study. Within the framework of this question, several sub-questions were determined, which are as follows: how can the concept of biomorphic design and affordances be linked? Can the Voronoi diagram offer innovative and creative play in opportunities to children's playgrounds? In this context, the hypothesis of the research was formulated as "applications of parametric forms with a biomorphic approach can be applied to the design process of children's playgrounds and can bring aesthetic design solutions together with the concept of affordances, offering new play opportunities".

This study[1] first explains through examples what biomorphology is, how it works and the extensions it offers to scientists working in the design field. The case study focused on Voronoi structures in nature, which inspired the research, and collected data for the project. As a result of the information gathered, the design of the children's playground was started, using Rhinoceros, a computer-aided design program, and Grasshopper, its plug-in. Necessary parameters and references for the project were determined, and through this research, a new generation playground, designed with a biomorphic approach, was modeled in three dimensions and visualized prepared, which could meet the needs of today's children. With the design obtained, an attempt was made to achive answers to the research question with the opinions of expert evaluation and the hypothesis was tested.

Theoretical framework

Biomorphic design

Bio means the combination of form expressing the relationship of life, living phenomena or living organisms, and *morphology* explains features collectively arising from the structure and form of an organism or its parts. From this point of view, *biomorphology* is a branch of science that studies the structure, forms, and physical properties of living beings. In design disciplines in general, *biomorphy* is the term used to describe *abstract forms derived from or resembling biological organisms* [10, p. 44]. Biomorphology is a science of structure that studies living organisms and the arrangement of their components such as organs, tissues and cells [11, p. 17].

The concept of biomorphology is widely used in many fields such as literature, art and architecture. Probably one of the most important reasons for this is that scientists who study the morphology and evolution of various living beings in the field of biology present their findings through "drawings". One of the most referenced sources on the subject is the drawings of Ernst Haeckel, an evolutionist and zoologist. Haeckel sought to reveal a mathematical formula for the morphological development of living beings [12]. For example, René Binet's World's Fair (1900) is a design in which a living organism is depicted throughout a building, with reference to the shape of protozoa [11].

Calatrava, who today often uses a biomorphic approach, takes a zoomorphic approach based on a bird's wing in his design for the Milwaukee Art Museum. Similarly, Frank Gehry, who imitates nature, used a biomorphic approach to design the Olympic Fish Pavilion sculpture made of glass, steel and metal. Throughout the history of architecture, many nature-inspired designs have taken their place in architectural literature.

Parametric design

Parametric design can be considered one of the emerging CAD technologies. In particular, the "creativity" it supports and the unique forms or styles it generates have attracted the interest of designers. Parametric design also has the potential to contribute to the development of new approaches in architectural design and research. The mathematical underpinnings of parametric design emphasize a wide range of impact from design optimization [13] to design innovations in complexity and emergent forms [14]. For example, its support for extensive productivity and design exploration has enabled the study of "responsive and performative" environments [15], [16]. In addition, some researchers argue that parametric design is fundamental to creativity through design exploration in the conceptual design phase, where variations can be generated by alternating between design parameters, topological relationships, and rule algorithms.

Affordances

In the 1960s and 1970s, ecological psychologist James J. Gibson developed concept of "affordances" in relation to the environment's capacity to act. *The affordances of the environment are what it offers the animal, what it provides or furnishes, either for good or for ill* [17, p. 127]. Gibson argued that the environment consists of affordances and that these action affordances are the basic objects of perception. That is, we perceive the environment in terms of what behavior it enables. Following Gibson, Harry Heft [18] developed an ecological approach to children's behavior, he suggested that we need to describe children's environment not in terms of forms, but in terms of possibilities. In fact, what matters to the playing child is not the form of the environmental furniture, but its functional meaning, i.e., what behaviors it enables.

Drawing heavily on Herbert F. Wright's et al. [19] detailed observational study of a seven-years-old boy's activities on an ordinary day, Heft [18] presented a preliminary

[1] This article is derived from the thesis entitled "Parametric playground design with biomimetic design approaches" written by Ujal Abbaslı at Gazi University in 2019.

taxonomy of affordances in children's outdoor environments. Over the years, this taxonomy has been used and extended by environmental psychologists who study children's play behavior (e.g., [20], [21]). For example, Marketta Kytta [22] used an expanded version of the taxonomy to assess differences in play opportunities in urban and rural settings in Finland and Belarus [22]. Similarly, Ingunn Fjørtoft [23] used the concept of affordances to describe the natural environment "as a playground for children". And more recently, Nora Charlotta Fagerholm and Anna Broberg [24] defined the child-friendly environments in terms of independent mobility and updated affordances.

It is very important that the playground arrangement can ignite in the child the motivation to creative play. Playgrounds that deny the child, do not give the child a chance to engage, participate, manipulate, can be called a lack of choice and interaction. The role of the playground is to motivate the child to play creatively within the playground. A playground that gives the child too many cues takes away the child's ability to take initiative and act out of a creative response to curiosity.

Affordances providing biomorphic-parametric playgrounds

The single-gyroid symmetry was first discovered in 1967 by Vittorio Luzzati et al. as a cubic phase occurring in strontium soap surfactants and in pure lipid-water systems. In 1970, Schoen identified the minimal gyroid, therefore also called the Schoen G surface [25].

Gyroid surfaces has been discovered in the cuticular structure of butterfly wing scales. This structure is made of chitin and air, serving as a biological photon crystal to produce iridescent colors.

Based on the gyroid structure, climbing elements have been constructed in the playgrounds at the Exploratorium in San Francisco. First playground is located outside of exhibition and made of 260 sheets of plywood. The second playground designed as gyroid climber. Children are exposed to an immersive climbing experience as they move through a minimal surface structure. This gyroid playgrounds offers visitors whole-body exploration and the opportunity for an aesthetic appreciation of geometry.

A similar role is fulfilled by Crater Lake Pavilion designed by 24° Studio and exhibited at the 2011 Kobe Biennale from October 1 to November 23. The project was one of the winners of the Shitsurai Art International Competition organized by the city of Kobe. This multifunctional environmental installation serves as a gathering place where each surface can be used as a seating area for visitors to contemplate the surroundings, thus griggering social interaction. The gentle surfaces of the hill invite people from many generations by providing spatial conditions that allow interaction with the landscape space like a play device, relaxing in the shade of the mount, and socializing by siting in the preferred order. Children in particular were interested in this installation. Parametric surfaces create differentiation for different play activities. Different parts of the playground allow different behaviors for children, allowing them to play the way they want.

From both examples, it became obvious how nature-inspired design with a parametric approach can offer very creative and interesting forms, surfaces and structures. Thus, implementing these forms, surfaces and structures into a playground design can make a designed playground very successful in terms of attractiveness. Because many studies on children's behavior in playgrounds show that standard playgrounds are actually undesirable.

Case study: Voronoi playground design with biomorphic approaches

Design development process

Prior to the design process for the children's playground, it was decided which natural phenomenon would be used as a reference from nature for the planned Voronoi diagram. In this context, it was considered that the structure of the dried seed of *Echinocystis lobata* could coincide with the concept of accords.

Having definied the referential essence for the Voronoi diagram, it would be appropriate to mention what is meant by the second concept, affordances, which guides the design. According to Gibson, affordance is a concept that represents the creation of an object/tool to enable a certain action. He also states that the affordances around us contribute to the creation of good or bad actions [17]. Therefore, when the dried seeds of the *Echinocystis lobata* plant are examined and viewed as an object, it can be seen that possible actions can be created by the object, according to Gibson's definition. In addition, Heft [18], who proposed that children's physical environments be defined not in terms of forms, but in terms of engagement, stated that what behavior or action these forms provide is more important to a child's play than the forms found in playgrounds. Given these judgments, it was deemed appropriate to use the dried seed of *Echinocystis lobata* as a source of inspiration in the design of children's playgrounds.

At the first stage of such a project, algorithms should be used to represent the Voronoi diagram and produce it [26]. The project car ried out in the article uses the algorithm offered by the Grasshopper software. The cells created by the Voronoi diagram, the surfaces, the lines in them in terms of the concept of affordances invite children to act perceptually. Therefore, in such a project it is more appropriate to use the Voronoi diagram in three dimensions. If the diagram in question is to be used in three dimensions, it is necessary to use another component – Voronoi3D. As you can see in Figure 1, the three-dimensional Voronoi diagram was created by connecting the vertical center points of all the lines connecting the points using the same algorithm, taking randomly placed points in the space as a reference.

Deciding on the parameters and factors in the matrix table that should be created after this step, they should be considered according to the three-dimensional application of the Voronoi diagram. The width, length, height and structure of the playground were specified as the selected parameters. These parameters, which will determine the design of the children's playground, will vary according to the national and international standards for playgrounds.

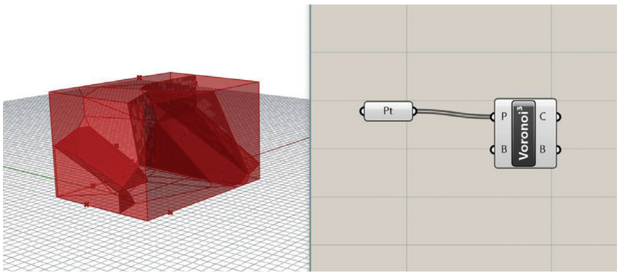

Fig. 1. Three-dimensional drawing of Voronoi diagram
(elaborated by U. Abbasli)

Il. 1. Trójwymiarowy rysunek diagramu Woronoja
(oprac. U. Abbasli)

After deciding on the parameters and factors shown in Table 1, the design problem is better defined. The width and length of a playground must always take into account the number of children who will play on it. In addition, in order to implement playground standards, the height of the playground must comply with the fall height standard, and the structure that will make up the playground is also to comply with these standards. To apply the concept of affordances, it is important that the surfaces and spaces formed in the structure invite children to engage in physical activities. The design problem thus created was used to develope a digital model for the next phase of the project.

After defining the design problem, the parameters in the matrix table (Table 1) were created in Grasshopper software. It is possible to define the parameters such as width, length, and height in the table as points in Grasshopper based on playground design standards (Fig. 2).

Each point is defined individually, so the Voronoi diagram can be controlled parametrically. In Figure 2a, height is defined as 2000 mm, width, and length as 4000 mm, and remaininig points are randomly placed parametrically in this area to form Voronoi cells. The Voronoi diagram component creates cells by referring to the defined points (Fig. 2b). Voronoi cells are updated parametrically when the position of any point in the *xyz* coordinate system changes or the number of points decreases and increases. In order for the created Voronoi cells to be used in solving a design problem, it is necessary to separate the surfaces, edges and ends of the cells edges. To do this, you can use the deconstruct brep command in Grasshopper.

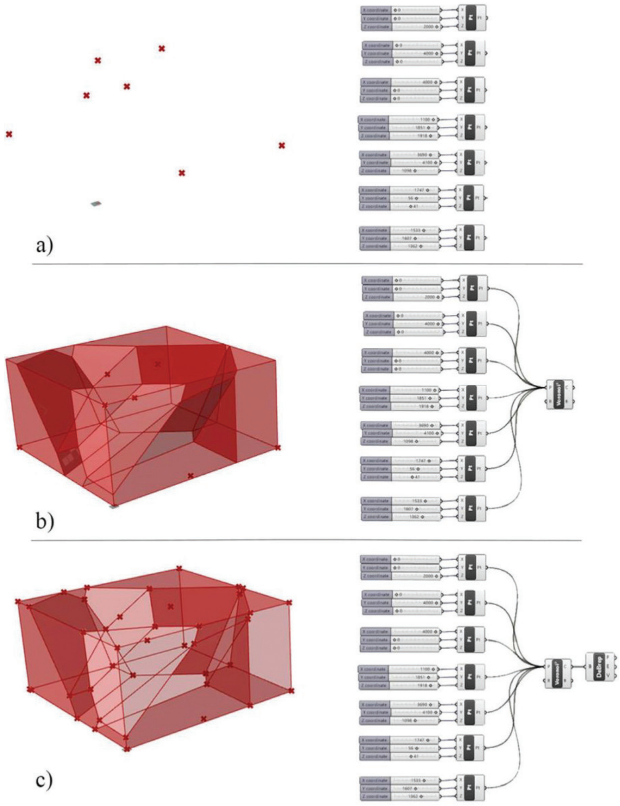

Fig. 2. Design in Grasshopper:
a) definition of points in Grasshopper,
b) implementation of the Voronoi diagram,
c) application of the Deconstruct Brep component
(elaborated by U. Abbasli)

Il. 2. Projektowane w Grasshopper:
a) określenie punktów w środowisku Grasshopper,
b) wprowadzenie diagramu Woronoja,
c) zastosowanie komponentu Deconstruct Brep (oprac. U. Abbasli)

Table 1. Parameters and factors matrix table (elaborated by U. Abbasli)
Tabela 1. Macierze parametrów i współczynników (elaborated by U. Abbasli)

Parameters	Width	Length	Height	Structure
Factors				
Number of children	The width of the playground should cover the number of children to play.	The length of the playground covers the number of children to play.	–	–
Standards for the playground	–	–	The height of the playground must be according to the fall height standard.	The structure must meet playground standards.
Affordances	–	–	–	The surfaces and spaces formed in the structure should invite children to physical actions.

To “create the structure”, another parameter in the matrix table (Table 1), you could define the edges separated by the deconstruct brap component as curves and create a structure by referring to these curves (Fig. 2c).

After creating curves using the curve component, you need to give these curves a thickness so that you can apply the affordances concept, which is one of the parameters in the matrix table. The curves created in Figure 3 show spheres arranged using spherical components. The planar component and the surfaces between them are then knitted, and the thickness of this structure is determined by the radius parameter, which depends on the sphere component. The softness level is then determined using the structure level parameter created with the WBCatmullClarck component in Figure 4.

The gaps and obstacles in this structure, created using a Voronoi diagram of the dried seeds of the *Echinocystis lobata* plant, are added parametrically and invite children to physical activities. The list item component is used to parametrically control barriers between structures. Using the list item component, surfaces previously created with the deconstruct brep component can be parametrically ordered with the index component and the Voronoi diagram can be adjusted to the desired surfaces in two dimensions for design integrity (Fig. 5)

Finally, by applying the parametric algorithm seen in Figure 6 to the parametric model created, it will be possible to obtain children’s playgrounds in different sizes by changing the parameters previously specified in the matrix table. In the next step describes the production of three different sizes of parametric playgrounds using the algorithm we developed.

Using the developed algorithm, three different parametric playground designs were made. To make each of the playgrounds, different sizes of playgrounds were achieved by changing the positions of the points forming the Voronoi diagram in the *xyz* coordinate system by changing the data in the algorithm. The construction of the space between the list element and the structure was defined parametrically. The first parametric playground has dimensions of 4000 × 4000 × 2000 mm and can accommodate 6–8 children playing together (Fig. 7a).

The second parametric playground measures 4000 × 6000 × 2000 mm and 10–12 children can play together (Fig. 7b).

In the third playground, the size is 2000 × 4000 × 2000 and it has the capacity for between 4–6 children to play (Fig. 7c).

These playgrounds designed using a parametric algorithm are an example of an adaptation of the Voronoi diagram. The playground’s manufacturing material, which was designed using a biomimetic approaches to design, is intended to be a sustainable and environmentally friendly material. However, both the structure and the playground’s obstacle boards are intended to be made of wood.

Expert opinions and evaluation of the design

In order to test the hypothesis that the biomimicry-based children’s playgrounds designed within the scope of the article would support the concept of affordance, experts who are child development specialists and/or preschool teachers were interviewed, as it was not possible to analyze the experiences with children who would be the users of the projects.

An information report was provided to the experts for use in the interview process. This information report included the motivation, purpose and reasons for proposing the children’s playground project, as well as visualizations of the project and questions about the current playground and the proposed project. The prepared questions were

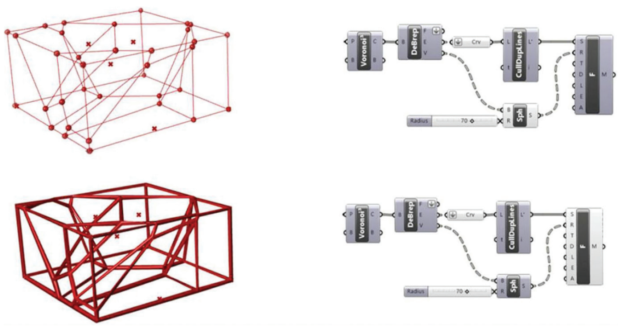

Fig. 3. Flatten component in Grasshopper (elaborated by U. Abbasli)

Il. 3. Zastosowanie komponentu Flatten w Grasshopperze (oprac. U. Abbasli)

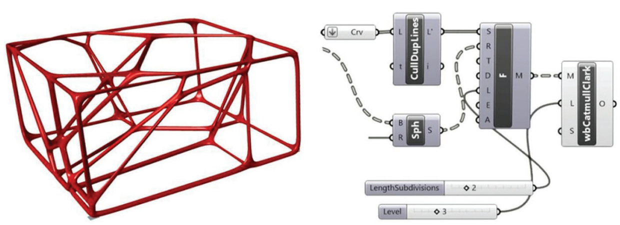

Fig. 4. WBCatmullClarck component in Grasshopper (elaborated by U. Abbasli)

Il. 4. Zastosowanie komponentu WBCatmullClarck w Grasshopperze (oprac. U. Abbasli)

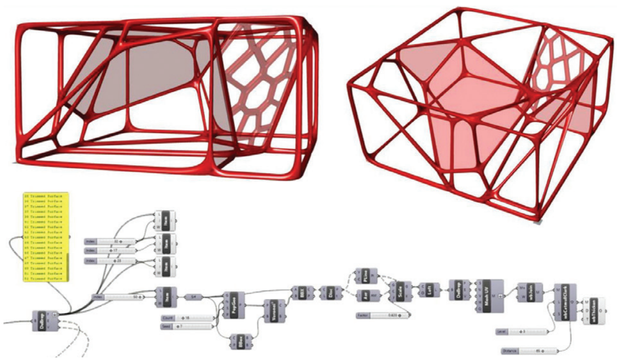

Fig. 5. Two-dimensional application of List item component and Voronoi diagram to surfaces in Grasshopper (elaborated by U. Abbasli)

Il. 5. Dwuwymiarowa aplikacja komponentu Lista item i diagramu Woronoja do powierzchni w Grasshopperze (oprac. U. Abbasli) sent to 6 experts actively working in the field of child development via email. In the interviews explained the topic and asked for detailed answers to the prepared questions. The answers provided by the experts were analyzed, and each descriptive adjective that emerged from the analysis was interrogated comparatively in both traditional playgrounds and the suggested playground. Questions prepared in this context were divided into two parts; the first part collected participants' options on existing children's playgrounds that they had used during the education pro-

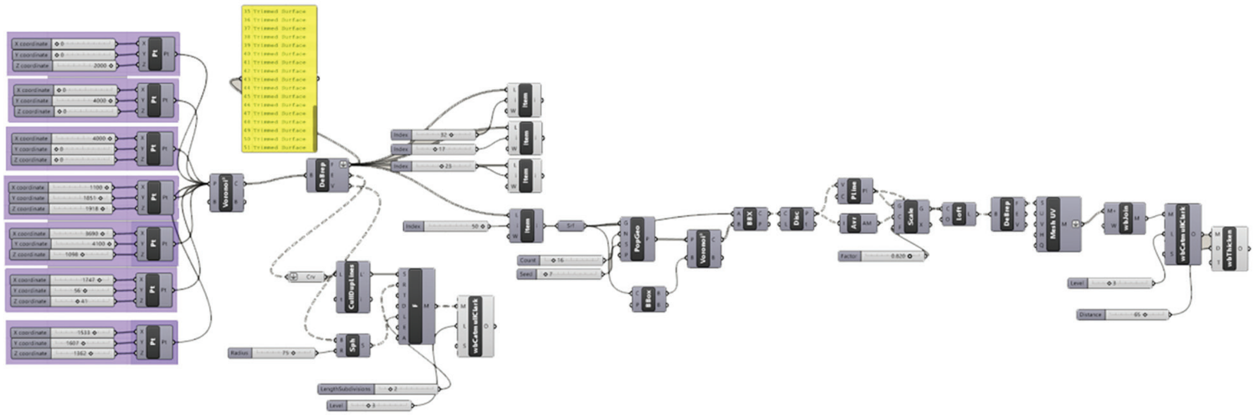

Fig. 6. Parametric playground algorithm in Grasshopper (elaborated by U. Abbasli)

Il. 6. Algorytm parametrycznego placu zabaw w Grasshopperze (oprac. U. Abbasli)

Fig. 7. First parametric playground design: a) first, second, c) third (visualization by U. Abbasli)

Il. 7. Projekty parametrycznego placu zabaw: a) pierwszy, b) drugi, c) trzeci (oprac. U. Abbasli) cess, and in the second part on the evaluation of suggested children's playgrounds.

Evaluation of existing children's playgrounds

1. How would you rate the playgrounds you use in your education process in terms of the play opportunities they offer?

All participants said that the game elements in traditional playgrounds are uniform and do not provide children with opportunities for creative play. In addition, they stressed that existing children's playgrounds are insufficient to meet children's physical, spiritual, mental and social needs in terms of both quality and quantity. Figure 8 shows participants' overall assessments of traditional/existing playgrounds. All commented that the areas are "limited" and "boring".

2. When evaluating the playgrounds you use in the educational process, using the concept of affordances, do you think they offer children opportunities social and creative play?

Participants say that the traditional/existing playgrounds they have used in the educational process partially or not at all meet this need. Two of the experts surveyed said they had removed existing playgrounds in the educational environments where they worked for these reasons. Figure 9 shows the response given to the question about participants' evaluation of traditional playgrounds in terms of affordances.

3. Do you think playground design works with contemporary and adventure themes will be more appealing to children?

Experts stressed that unlike traditional playgrounds, contemporary and adventure playgrounds also offer children opportunities to develop problem-solving skills, explore, develop their imagination and create new games by playing with tools (Fig. 10).

Evaluation of proposed playgrounds

In the second part of the interviews, participants were interviewed on visualizations of the children's playground project. Below are the charts prepared as a result of the questions asked to the participants in this interview and the responses given by the participants.

1. How do you rate the proposed playground project in terms of the new play opportunities it offers?

Experts defined the proposed playgrounds as areas where children can play while having fun and learning at the same time, unlike traditional playgrounds. They said that such areas designed according to the children's needs and creativity increase the variety of games, take away the uniformity of the play environment, and provide opportunities to play more than one game in one area. Figure 11 reflects the responses given by the experts to this question.

2. Do you think the proposed playground design offers social and creative play opportunities?

Participants said that the proposed playgrounds support group games and children can create various games using their own imagination. In addition, children stressed that

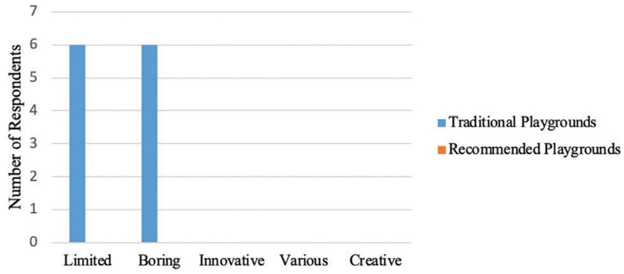

Fig. 8. General assessment of existing playgrounds by experts (elaborated by U. Abbasli)

Il. 8. Ogólna ekspercka ocena istniejących placów zabaw (oprac. U. Abbasli)

Fig. 9. Experts' evaluation of traditional/existing playgrounds in terms of affordances (elaborated by U. Abbasli)

Il. 9. Ocena przez ekspertów tradycyjnych/istniejących placów zabaw pod względem ich afordancji (oprac. U. Abbasli)

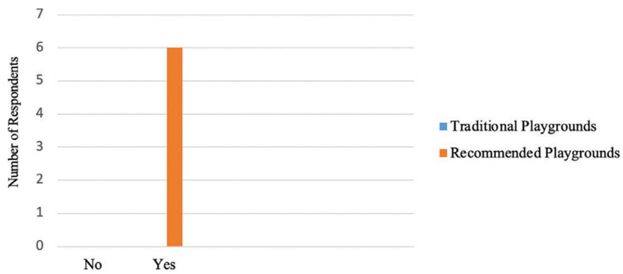

Fig. 10. Experts' assessment of contemporary and adventure playgrounds (elaborated by U. Abbasli)

Il. 10. Ocena współczesnych i alternatywnych placów zabaw dokonana przez ekspertów (oprac. U. Abbasli)

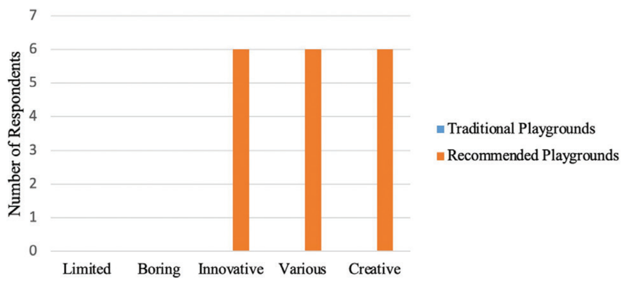

Fig. 11. General assessment of the experts' proposed playgrounds (elaborated by U. Abbasli)

Il. 11. Ogólna ocena ekspertów dotycząca proponowanych placów zabaw (oprac. U. Abbasli)

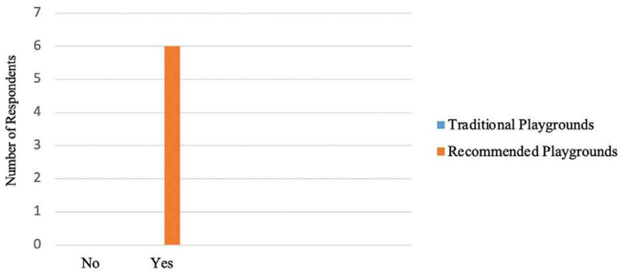

Fig. 12. Evaluation of the proposed playgrounds by experts in terms of providing social and creative play opportunities (elaborated by U. Abbasli)

Il. 12. Ekspercka ocena proponowanych placów zabaw pod kątem zapewnienia możliwości interakcji społecznych i kreatywnych (oprac. U. Abbasli)

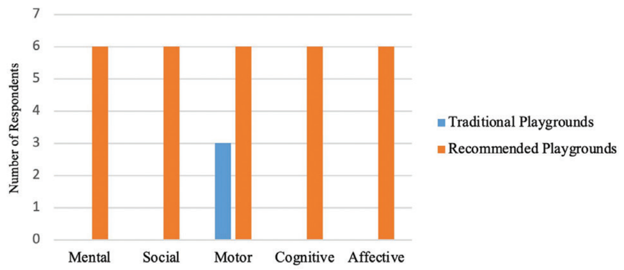

Fig. 13. Experts' comparison of proposed playgrounds with existing playgrounds (elaborated by U. Abbasli)

Il. 13. Eksperckie porównanie proponowanych i istniejących placów zabaw (oprac. U. Abbasli)

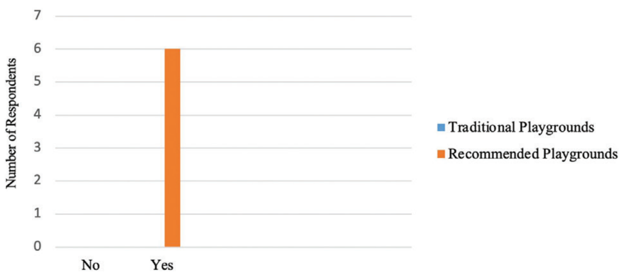

Fig. 14. Experts' evaluation of suggested playgrounds in terms of affordances (elaborated by U. Abbasli)

Il. 14. Ekspercka ocena proponowanych placów zabaw pod względem afordancji (oprac. U. Abbasli)

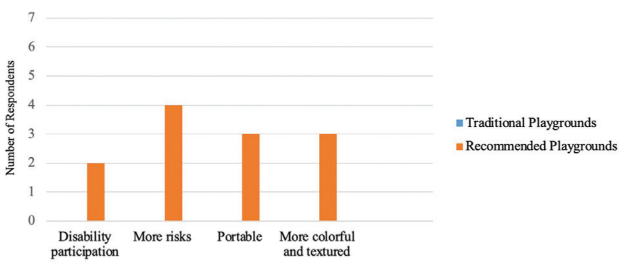

Fig. 15. Recommendations of experts to proposed playgrounds (elaborated by U. Abbasli)

Il. 15. Rekomendacje ekspertów dotyczące proponowanych placów zabaw (oprac. U. Abbasli)

"learning" activities will increase through games, such as belonging to a group, taking responsibility in a group, and cooperating with group members, by using these playgrounds. Figure 12 reflects the experts' evaluations of the proposed playgrounds in terms of providing opportunities for social and creative play.

3. Do you think that the proposed playground project will contribute to children's mental and physical fitness?

Experts say that the play opportunities offered by the proposed playgrounds allow the child to explore the environment, recognize/diferentiate objects and solve problems, while providing many possibilities such as size, shape, color, size, weight, volume, measuring, counting, time, space, distance, space. They also found that they can teach many concepts and many mental operations, such as matching, classification, ordering, analysis, synthesis and problem solving (Fig. 13). Three experts focused on the contribution of existing playgrounds to motor development.

4. Evaluating it in terms of the affordances concept described above, does the proposed children's playground design coincide with this concept?

Participants said that the proposed playgrounds are unusual, can be more attractive to the child, can offer an environment without restrictions, and offer rich opportunities for play in the context of the concept of engagements, as they create an environment for more movement and interaction with multifunctionality and transition between games (Fig. 14).

5. Evaluating the proposed playground project in terms of children's physical and mental development, what suggestions would you make to take it further?

The experts suggested that, in addition to the existing proposals, the playground should include activities that support the rehabilitation of children with physical disabilities and look for ways to include children with physical disabilities in these areas. They also commented on the possibility of moving the playground according to the changing needs of the children and providing opportunities for children to take more risks. Figure 15 shows the distribution of responses to this question.

As a result of the interviews, as can be understood from the experts' opinions, children's playgrounds designed with biomimetic approaches have the potential to meet the needs of today's children and will contribute to child development in many ways. In this context, it can be concluded that biomimetic approaches and applications of parametric forms can be adapted to the "children's playgrounds design process" and have the potential to create new play opportunities in terms of the concept of affordances.

Conclusion

Play is one of the most important tools for a child to explore his or her relationship with the world, so the physical boundaries of a place, that is referred to as a "playground" are important for children's physical and psychological safety. However, this limitation should not prevent children from playing creatively. The fact that playgrounds do not restrict children's activities and provoke a child's sense of curiosity plays an important role in a child's physical and mental development.

In the digital age we live in, the emptying of playgrounds has accelerated as children spend more time with technological toys. In addition to this technological addiction and emptying of playgrounds, this brings a lot of psychological and physical damage. There is a need for creative and attractive new playgrounds that will encourage children to return to their play areas. Because today's traditional playgrounds cannot meet the expectations of the children of digital age.

As explained in the scope of the research, the biomorphic approach can provide an opening in playground design that will encourage children of this age to play outdoors and offer new and creative play opportunities according to their diverse expectations and abilities. The main reason is the potential to add new dimensions to children's playground design through research to understand the colors, patterns, designs and forms found in nature, as well as their construction and the process behind it all.

With these considerations in mind, this paper examined existing Voronoi patterns in nature and adapts them to the design process of children's playgrounds using digital design tools. The reason for choosing the Voronoi diagram is that the mathematical pattern it represents can be adapted in both two dimensions and three dimensions. The structural structure created by this two- and three-dimensional pattern has the potential to offer innovative and attractive opportunities for children to play with the concept of commitment. The paper develops a parametric algorithm to control the Voronoi diagram using digital tools. With this algorithm, it is possible to adapt the design to playgrounds of different sizes and try out an almost unlimited number of variations by changing only the parameters in the algorithm depending on the number of children to play with.

As explained in the scope of the research, it is clear that learning from nature has the potential to design playgrounds that will encourage children of this age to play outdoors and offer new and creative play opportunities according to their diverse expectations and abilities. The children's playgrounds developed in the last part of the study can provide a new perspective through the method adapted in the design process and can motivate designers to continue their work in this field, and can lead to designs that can contribute to the "return of children to playgrounds" and at the same time to their "physical and mental development".

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Abstract

A parametric design offering affordances for the children of digital world: playground inspired by Voronoi

Playing is one of the most important tools for children to explore his/her connection with the world. The role of play is very significant in children's physical, psychological, mental, and social development. However, today two major facts keep children in more indoors slowing down/weakens the establishment of this connection. The first is industrialized cities and the second is the digital world. Thus, to motivate children to return to outdoor play and playgrounds, engaging and attractive play experience should be created for them. It can be claimed that traditional playgrounds do not meet the needs of today's children. This paper examines the role of bio-morphology in designing modern and creative playgrounds that could meet the needs of today's children. This study claims that, the colors, patterns, forms and structures in nature can provide new approaches to design of novel playgrounds for today's children. Biomorphic design approach can offer forms and structures that may create "affordances" for children of digital age. Through this hypothesis, the examination of Voronoi diagrams into the design process of playground with digital design tools a playground was designed, discussed within the context of creating "affordances" for children and final designs was subjected to expert evaluations.

Key words: biomorphic, playground for children, affordances, parametric design

Streszczenie

Parametryczny projekt dostępny dla dzieci cyfrowego świata: plac zabaw inspirowany diagramem Woronoja

Zabawa jest bardzo istotna w rozwoju fizycznym, psychicznym, poznawczym i społecznym dzieci, stanowi przy tym jedno z najważniejszych narzędzi w odkrywaniu ich relacji z bliższym i dalszym otoczeniem. Ze względu na atrakcyjność świata cyfrowego, dzisiejsze dzieci dużo czasu spędzają w pomieszczeniach, co nie sprzyja nauce budowania związków międzyludzkich i podnoszeniu własnej sprawności. Dlatego też warto dzieci motywować do powrotu na świeże powietrze, tworząc dla nich atrakcyjne place zabaw, które mogą być użytkowane w niestandardowy i kreatywny sposób. W niniejszym artykule przeanalizowano rolę biomorfologii w projektowaniu nowoczesnych placów zabaw, które mogłyby stanowić wyzwanie dla dzieci. Okazuje się bowiem, że kolory i wzory występujące w naturze mogą stanowić inspiracje w nowym podejściu do projektowania urządzeń dziecięcych zabaw. Zaobserwowano też, że biomorfologia może oferować formy i struktury, które służą „afordancjom" rozumianym jako interakcje ze środowiskiem. Mając na uwadze wskazane spostrzeżenia, przedstawiono autorski projekt placu zabaw, który powstał przy użyciu diagramów Woronoja. Projekt został poddany ocenie ekspertów, którą również zaprezentowano w artykule.

Słowa kluczowe: biomorfologia, place zabaw, afordancja, projektowanie parametryczne