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## BIOMIMICRY ELEMENT APPLICATION IN THE INTERIOR DESIGN PRODUCT DEVELOPMENT

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**Introduction.** Environmental issues have different social and economic causes. The demand on natural raw materials has led to the disappearance of different animal species, yet human waste is one of the most important elements of global and local pollution. According to the results of the survey, 56% of those surveyed in Latvia have recognised that they prefer to choose those brands that are in favour of a clean environment. Sustainability and environmentally friendly farming are becoming more and more wide spread and topical, so the authors want to explore whether biomimicry used in a product development, increases the opportunities for more sustainable products.

**Aim and tasks.** The main aim of this research is to create a framework for using biomimicry to manufacture new interior design products. The interior design project is needed to improve the quality of life in a society. The intention for this research is to help to develop the quality of long-term solutions for the society's daily life in accordance with nature. An interior design, which is created close to natural processes using all possibly available materials and products on the basis of biomimicry methods.

**Results.** This article explores the ways in which biomimicry techniques, based on the Design Spiral and Janine Benyus Biomimicry Design Lens Principles of Life, can be combined with the design process of an interior design, thereby to create a framework with the help of which a designer works and creates a sustainable interior design. The interior design is a complex process, it is more than just the location of objects in a room or just a decorative supplement that covers the structure of a building, it is a necessary dimension that actually transforms a simple architectural space into a habitable place with a desired order, stability, and individuality.

**Conclusions.** The article proposes a basis for the application of biomimicry in the development of an interior design product. The main difference between an interior design and the methodology of biomimicry is that in an interior design process the main question needs to be biologized from "What do I want to create?" to "What do I want to achieve with my design?". Also, in an interior design process there are phases to follow to create a design, like there are phases to create in biomimicry based products or processes. The most important points in the creation of the framework are the milestones at which the process of designing interior design should begin to be biologized. Changing the order of the Design Spiral phases and adjusting it to the designing points of an interior design, a system can be created in which all stages of the Design Spiral are connected with the interior design process. Milestones show the progress of a project where each milestone has the actions or activities to be performed, respectively.

**Keywords:** product development, biomimicry, interior design products, Design Spiral.

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## ВИКОРИСТАННЯ ЕЛЕМЕНТА БІОМІМІКРІЇ ПРИ РОЗРОБЦІ ТОВАРІВ ДИЗАЙНУ ІНТЕР'ЄРУ

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**Вступ.** Проблеми навколишнього середовища мають різні соціальні і економічні причини. Попит на природну сировину призвів до зникнення різних видів тварин, але відходи життєдіяльності людини є одним з найбільш важливих елементів глобального і локального забруднення. Згідно з результатами опитування, 56% опитаних в Латвії визнали, що вважають за краще вибирати ті бренди, які виступають за чисте довкілля. Сталий розвиток і екологічно чисте сільське господарство стають все більш поширеними і актуальними, тому досліджується питання, чи збільшує можливості для створення більш екологічних продуктів від використання біомімікрії при розробці продукту.

**Мета і завдання.** Мета цього дослідження – створити основу для використання біомімікрії для виробництва нових продуктів для дизайну інтер'єру. Дизайн-проект інтер'єру потрібен для поліпшення якості життя в суспільстві. Мета цього дослідження – допомогти розробити якісні довгострокові рішення для повсякденного життя суспільства із меншим впливом на природу на основі використання всіх можливих матеріалів і продуктів на основі методів біомімікрії.

**Результати.** У цій статті досліджуються способи, за допомогою яких методи біомімікрія, засновані на принципах життя дизайн-спіралі і біомімікрії Джанін Беніус, можуть бути об'єднані з процесом проектування інтер'єру, тим самим створюючи основу, за допомогою якої працює дизайнер і створює екологічний дизайн інтер'єру. Дизайн інтер'єру як складний процес, це необхідний вимір, який фактично перетворює архітектурне простір в житловий простір з бажаним порядком, стабільністю і індивідуальністю.

**Висновки.** У статті запропонована основа для застосування біомімікрія при розробці предмета інтер'єру. Основна відмінність між дизайном інтер'єру і методологією біомімікрія полягає в тому, що в процесі дизайну інтер'єру головне питання повинен бути біологічно відділений від “Що я хочу створити?”. на “Чого я хочу досягти за допомогою свого дизайну?”. Крім того, в процесі дизайну інтер'єру є етапи, яким необхідно слідувати для створення дизайну, наприклад, етапи створення продуктів або процесів на основі біомімікрія. Найбільш важливі моменти в створенні каркаса – це віхи, на яких процес проектування інтер'єру повинен трактуватися з точки зору біології. Змінюючи порядок етапів спіралі дизайну і адаптуючи його до точок проектування інтер'єру, можна створити систему, в якій всі етапи спіралі дизайну пов'язані з процесом дизайну інтер'єру. Спіралі показують прогрес проекту, в якому кожна містить дії або дії, які необхідно виконати.

**Ключові слова:** розробка продуктів, біомімікрія, предмети інтер'єру, спіраль дизайну.

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**Introduction.** Environmental issues have different social and economic causes. The need for natural raw materials has led to the disappearance of different animal species, yet human waste is one of the most important elements of global and local pollution. According to the results of the survey, 56% of those surveyed in Latvia have recognised that they prefer to choose those brands that are in favour of a clean environment. Sustainability and environmentally friendly farming are becoming more and more widespread and topical, so the authors want to explore whether biomimicry used in a product development, increases the opportunities for more sustainable products. The aim of the research is to explore the situation and its potential for the use of biomimicry in the production of interior design products.

In science and technology, new ideas often come from exploring nature. Biomimicry is a science that inspires solutions to human issues researching natural themes, processes and systems [1-7]. Biomimicry has been studied only over the last century, while the world has developed effective life methods over 3.8 billion years. The world is the oldest and smartest teacher to keep the processes in line with all living organisms. The history of humanity is relatively short, so a climate change is experienced, which is detrimental to the future of the world. Biomimicry, literally translated, as the imitation of life. The aim of Biomimicry is to draw inspiration from the solutions in nature and to adapt its principles to man-made engineering. A Biomimicry approach aims to give a preference to “choices” which nature has been testing millions of years and has come to the conclusion what works and works the best and what does not work at all. Biometric-based designs will ultimately allow people's production to be more efficient, flexible and sustainable [8].

Scientists, architects and specialists from other sectors are increasingly addressing this issue by reinforcing the sustainability approach in their own areas. The introduction of more sustainable solutions in its work often explores nature and its processes. Although humanity has always watched and studied nature and its processes to solve issues, biomimicry and its concept are relatively recent, today attributed to

the US scientist Jenina Benjasas, who used the term in her book “Biomimicry: Innovation Inspired by Nature”. This term is derived from the Greek word *bios*, which means life and *mimicos*, which means mimicking or imitating.

Biomimicry is a deliberate imitation of the geniality of nature. It is an interdisciplinary approach that combines two often unrelated worlds: nature and technology, biology and innovation, life and design. Biomimicry practices tend to build time-tested life wisdom in a design table to inform about human solutions that create life-friendly conditions. To put it simply, biodiversity is a way to look at sustainable solutions by borrowing life drawings, chemical recipes and ecosystem strategies. Biomimicry connects us in the most modern way that matches, smooths and integrates human species into the natural processes of the Earth [9].

The use of biomimicry in the interior is quite complicated because the interior a priori is a ready-made architectural object with walls, windows, doors, etc. designed by someone else and possibly not using biomimicry. Therefore, in an interior design, biomimicry can be applied on a small scale, such as the design of products, materials, plants' integration into a room, etc., focusing on the origin of a product and a material. The interior alone cannot exist without architecture, these two things go hand in hand. A building must be constructed at the beginning by biological methods, and then the interior will also be created by biomimicry.

**Literature review.** Nature has developed objects with a high performance using common materials. Understanding the functions of objects and processes found in nature can help people to replicate and create nanomaterials, nanodevices and processes. Biologically inspired design or an adaptation, or a derivation from nature, is called biomimicry. It means mimicking biology or nature. The concept of biomimicry is derived from the biomimesis of the Greek word. *Bio*, which means life, and the *mimesis* that means imitating. The word was invented in 1957 by polymathist Otto Schmidt, who developed a physical device in his doctoral research that simulated the electrical performance of nerves. Other words used are *bionica* (used in 1960 by Jack Steele from

Wright-Paterson Air Force Base in Dayton) and biomimicry, which in literature are more like deriving, copying or adapting nature (which is theoretically the same, yet biomimicry in its definition and expression includes a further part of biology, not just one of these qualities – the authors' comment) [10]. This science is based on the belief that nature follows the path of the least resistance (the least energy loss), while often using the most common materials to perform a task. Ideally, biomimicry should integrate principles that contribute to sustainability, such as cradle to grave, from the use of raw materials to recyclability [11].

Biomimicry is highly interdisciplinary. It includes understanding biological functions, structures and principles by biologists, physicists, chemists, and material scientists, as well as a variety of commercial interests in the development and manufacture of materials and appliances by engineers, material scientists, chemists, and other specialists. The concept of biomimicry first appeared in Webster's dictionary in 1974 and is defined as “a study on the formation, structure or function of biologically produced substances and materials (such as enzymes or silk) and biological mechanisms and processes (such as protein synthesis or photosynthesis), particularly to produce similar products with artificial mechanisms that simulate natural ones [10].

Biodiversity brings our current-day ideology closer to nature, using nature as a design inspiration to solve human issues in a sustainable way. Biomimicry binds the built-up environment to the natural world, trying to use nature as a model, as measuring a standard and a mentor. The rationale for this approach is that “the more our world looks and functions like this natural world, the more likely we will be adopted in this house that is ours but not ours alone” [12].

The word biomimicry is relatively young, yet our ancestors were looking for inspiration in nature for the development of various materials and devices many centuries ago. For example, the Chinese tried to make artificial silk about 3,000 years ago. Leonardo da Vinci, a genius of his time, studied birds flying and offered plans for flying machines. One of the first examples of biodiversity is birds' research to enable people to fly. Although Leonardo da Vinci did

not have a chance to create successfully a flying machine, he was a great birds' watcher to explore their anatomy and flying. He made countless sketches and notes about his observations and plotted flying machines alongside them [13].

Even interior design product development approach with biomimetics is not widely researched, but urban city design and architecture is well researched area of biomimetics [14- 20].

But there are a lot of knowledge that could be transferred from architecture to interior design, for example, textured building facades with cooling elements [21], envelope design buildings [22], construction materials [23] etc.

**Aim and tasks.** The main aim is to create a framework for using biomimicry to manufacture new interior design products. The interior design project is needed to improve the quality of life in a society. The intention for this research is to help to develop the quality of long-term solutions for a society's daily life in accordance with nature. An interior design is created that is close to natural processes using all possible available materials and products created based on biomimicry methods.

The authors looked at ways in which biomimicry techniques, based on the Design Spiral and Janine Benyus Biomimicry Design Lens Principles of Life, could be combined with the design process of an interior design, thereby to create a framework with which a designer works and creates a sustainable interior design.

The interior design is a complex process, it is more than just the location of objects in a room or just a decorative supplement that covers the structure of a building, it is a necessary dimension that transforms a simple architectural space into a habitable place with the desired order, stability, and individuality.

Each interior designer certainly starts and designs a new project differently, but the common thing is that mostly the rooms have a ready skeleton, i.e., walls, windows, doors' aisles, a ceiling height and an integral part of a customer's or a client's desires. The parameters for how walls' sizes, a ceiling height goes, of course, can be changed. Yet the beginning of a project for all designers is certainly similar.

Designers today are the ones who define what products to use. Given the current

sustainability and nature-friendly design of society, designers are more likely to choose such products. Therefore, ecological, natural, and nature-friendly products, not only in the fields of cosmetics or fashion, but also in the design of products and interiors, can also be found.

**Results.** The authors have researched two existing methods of biomimicry “Principles of Life” and Design Spiral.

Biomimicry 3.8 is the world's leading bio-inspired consulting company, offering advice in the fields of biological intelligence, professional training, and inspiration. This company uses biodiversity to help innovators to find new design solutions. They train professionals to become the next generation of biodiversity, sharing ways in which the wisdom of nature resolves humans’ issues. Biomimicry 3.8, founded and managed by Jenin Benyus, has developed Biomimicry Design Lens manual, which helps to create new designs using biodiversity thinking [9].

Biological thinking gives the context to where, how, what and why biomimicry is the part of any discipline or the scale of any design. Although similar to the methodology, biodiversity thinking is a framework designed to: help people to practice biodiversity by developing new products.

There are four areas where the biomimicry objective for the design process provides the highest value (regardless of the discipline in which it is integrated): actions, a scope, a detection, an establishment and an evaluation. Following the specific phases in each at the stage, they help to ensure that life strategies are successfully integrated into a human-made design [9].

The challenge in biology is a specific path with biographical thinking help. This is useful for scenarios where a specific issue arises and is being searched for biological solutions. This is particularly useful for a “controlled” setting, such as for a class setting, or for creating of an iterative (repeating) design process.

It is not surprising that the best result is when the action is repeated several times. From biology to a design, there is a very interesting and a specific path that fiddled through a biological thinking. This path is the most appropriate if the process starts with an

inspiring biological insight that wanted to be shown as a design. Biomimicry practices include three interrelated but unique components; the three basic components of biomimicry are the basis of biomimicry (See Fig.1).



**Fig.1 The Most Important Elements of Biomimicry**

Source: [24]

Life principles mean design activities based on nature and knowledge that: life on the Earth is interlinked and interdependent and covered by one and the same operating conditions (see in Fig.2.).



**Fig. 2. Life Principles**

Source: [24]

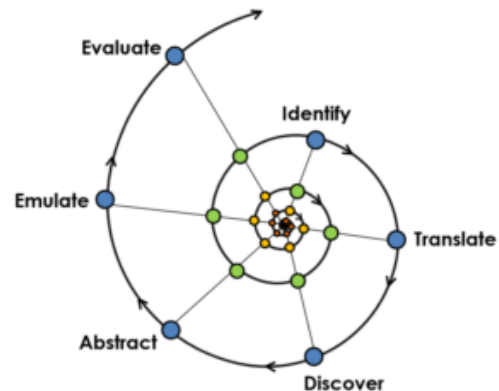
Life principles have developed a set of strategies that have existed more than 3.8 billion years. Life principles reflect these comprehensive models, which occur among species that survive and thrive on the Earth. Life principles integrate and optimize these strategies

to create life-friendly conditions. By learning from these for deep design lessons, we can model innovative strategies, assess their designs, compare to these sustainable criteria, and allow themselves to diminish the geniality of nature by using the Principles of Life as our future ideals [24].

*Biomimicry Theme Spiral* - this is another way of looking for more sustainable approaches. The principles were developed by industrial designer Carl HASTRICH. Spirals are everywhere because they perform a lot of functions, so it is not surprising that then, when Carl HASTRICH began to create a biomimicry design process, he used exactly those because the process of a spiral design does not only allow the use of the power of nature, but also lets to use our own creativity and imagination that are needed to solve the challenges we face today. Carl HASTRICH has strategic foresight of a designer who is committed to helping others navigate difficult issues and in positions to make a long-term success. He has been teaching design for ten years, and innovation at different levels, ranging from bachelor to professional activity, covering topics such as product and service design, system design and biomimicry [25].

The Biomimicry Design Spiral is a useful tool for learning phases that are crucial for a successful biomimicry design (Fig.3.).

It is used when someone is interested in solving a particular issue (challenge), or when you see the possibility of a design, and there is a desire to look for inspiration for biological models [26].



**Fig.3. Biological Design Spiral**

Source: [26]

*Combining the approaches.* The Spiral consists of six sections which, in the form of a spiral, may recur when dealing with an issue: identify, translate, discover, abstract, emulate, evaluate. The design Spiral is a slightly newer method and is based on the “Principles of Life” developed by Janine Benyus and is tailored for product development, so the authors compared this method with the design process of interior design (Table 1).

**Table 1. Comparison Between an Interior Design Process and a Design Spiral**

Interior design project	Design Spiral
<u>DEFINE TASK</u> 1. problem 2. goal 3. questions	<u>DEFINE</u> What do you want your design to achieve? <u>not</u> What do you want to create with your design?
<u>COLLECT</u> 1. Facts, data 2. What do you want to create?	<u>BIOLOGIZE</u> How does this process happen or does not occur in nature at all? How is this feature achieved in nature?
<u>ANALYZE</u> 1. Facts, data 2. Determination of key factors	<u>DISCOVER</u> Nature models; looking for leaders in nature who answer/solve a problem
<u>IDEA</u> G the general design of a concept (a collage, a color gamut)	<u>ABSTRACT</u> Key mechanisms or characteristics that make strategies successful
<u>PROJECT</u> Find the best solutions, the first option, products, colors, a final design	<u>EMULATE</u> Nature strategies, develop concepts and ideas based on nature strategies: Form, process, ecosystem
<u>EXECUTE</u> Project - ready on paper → project in life	<u>EVALUATE</u> How does it fit into the Earth system? Does the form match the function? What role does water play? Is it local? Is it recyclable? Have life-friendly conditions been created?
<u>EVALUATE</u> What has been done? How to improve future operations? How do I improve my work? Evaluation of your work for the further improvement.	<u>IDENTIFY</u> Develops and improves the design summary based on natural principles. Identify ways to improve your design.

The authors created such a comparison table to understand the similarity of the interior design process with the Biomimicry Design Spiral. The biggest difference is in the approach. If an interior designer usually asks the question "What do I want to create?", Then the biomimicry approach is to biologize the question and ask, "What do I want to achieve with my design?". If, at a design stage, a designer compiles and paraphrases the question "What do I want to achieve with my design?", a designer would be able, like nature, to solve the issue and the final product would be sustainable.

The main difference between an interior design and the methodology of biomimicry is that in an interior design process main question needs to be biologized from "What do I want to create?" to "What do I want to achieve with my design?".

Also, in an interior design process there are phases to follow to create a design, like there are phases to create in biomimicry-based products or processes.

The most important points in the creation of the framework are the milestones at which the process of designing an interior design should begin to be biologized. Changing the order of the Design Spiral phases and adjusting it to the designing points of an interior design, a system can be created in which all stages of the Design Spiral are connected with the interior design process (Table 2).

**Table 2. Project Milestones and Activities to be Performed by Biomimicry Elements**

Milestones	Activities
A site survey	Fact and data collection – measurements, photo fixations, wish hearings
Analysis	The analysis of facts and data. The start of a design, the definition of room functions. Finding nature models, identifying companies, identifying materials. Biomimicry approaches.
The Project's concept	Create a collage, create a mood map
Designing	The identification of a natural light, a plant implementation into a room, the prediction of local materials, the planning of a room functionality.
The Project's evaluation	The Elements of biomimicry, the elements of nature.
A final result	The Completed project

Source: created by authors

Milestones show the progress of a project where each milestone has the actions or activities to be performed, respectively. This is a phase to biologize.

A site survey, the first milestone, are important for starting a project. In this case, it is important to check where the windows are located, whether there is enough light in a room, which sides of the sky they face, which is one of the basic elements of benevolent Principles of Life, since nature works in sunlight. Also, for a man, being the part of nature, sunlight in the living space is important. Already at this stage of a project, biomimicry is applied. When this point is executed, you can start the next one (see Table 3).

**Table 3. Site Survey**

Milestone	Activity	Design Spiral adapted to interior design milestones	Design Spiral Phase
Site survey	The Collection of facts and data – measurements, photo fixation, wish hearing	–	1. DEFINE What do you want your design to perform? What do you want to create with your design?

Source: created by authors

At the analysis reference phase, local companies producing the necessary products from local or recycled materials should be identified and contacted. Based on the Principles of Life, locally accessible materials should be used in the design, so it is important to identify local manufacturers. At this stage, the project should start to be biologized (See in Table 4).

**Table 4. Analysis**

Milestones	Activities	Design Spiral adapted to interior design milestones	Design Spiral Phase
Analysis	Analyze facts and data. Design start, defining space functions. Identifying natural models, identifying businesses' identifying materials. Matching biological approaches.	<p><u>1. DEFINE</u> What do you want your design to do?</p> <p><u>3. REVEAL</u> Nature models; looking for leaders in nature who answer/solve the problem</p>	<p><u>BIOLOGIZE</u> How does this process take place or not in nature? How is this function achieved in nature?</p>

Source: created by authors

The project's concept phase is important for the user, the customer for whom the project is being created. At this stage, it is important to place products that have been identified at the previous stage, in order to introduce them to a customer (Table 5).

**Table 5. Project's Concept**

Milestones	Activities	Design Spiral adapted to interior design milestones	Design Spiral Phase
Project's concept	Create a collage, create a mood map	<p><u>5. EMULATE</u> Natural strategies, development of concepts and ideas based on natural strategies: Form, process, ecosystem</p>	<p><u>REVEAL</u> Nature models; looking for leaders in nature who answer/solve the problem</p>

Source: created by authors

The design phase is the most time consuming, as it requires to allocate the most time. At this point, it is important to design a room so that it corresponds to the function. Here you apply the basic element of the Principles of Life that the form suitable to a function. See all phases in Table 6.

**Table 6. Design and Final Results**

Milestones	Activities	Design Spiral adapted to interior design milestones	Design Spiral Phase
Design	The identification of natural light, the introduction of plants into a room, the forecasting of local materials, planning the functionality of a room.	<p><u>2. BIOLOGIZE</u> How does this process take place or not in nature? How is this function achieved in nature?</p> <p><u>4. ABSTRACTION</u> Essential mechanisms or features that make strategies successful</p> <p><u>7. IDENTIFIES</u> Develop a design summary based on natural principles. Identify ways to improve a design.</p>	<p><u>ABSTRACTION</u> Essential mechanisms or features that make strategies successful</p>
The assessment of the project	Biological elements, natural elements.	<p><u>6. ASSESS</u> How does it fit into the Earth system? Does the form match the function? What role does the water play? Is there a local solution? Is it recyclable? Is it possible creating life-friendly conditions?</p>	<p><u>EMULATE</u> Natural strategies, the development of concepts and ideas based on natural strategies: Form, process, ecosystem</p>
A final result	A finished project		<p><u>6. ASSESS</u> How does it fit into the Earth system? Does the form match the function? What role does the water play? Is there a local? Recyclable? Creating life-friendly conditions?</p>
The next step	A further development		<p><u>IDENTIFIES</u> Develop a design summary based on natural principles. Identify ways to improve a design.</p>

Source: created by authors

An interior designer is not one that can change the shape of a room, but he/she can make it more suitable for its function than it used to be. In order the design to be biomimicry-based at this stage, local material products should be provided for it in cooperation with local product manufacturers, this way supporting local producers and designers.



It is important to calculate accurately the amount of materials needed (e.g. floors, walls) so that there are no or as few surpluses as possible, since in nature all processes are waste-free and recycled. The presence of natural light, windows should be identified. Plants that fill the room with oxygen and bring it closer to nature should be brought into the interior. Following these principles, an interior becomes biomimicry based and sustainable.

When a project is completed, it is important to assess whether it has applied the above-mentioned principles, so that the design is bio-generated and therefore sustainable. If something has not been applied or is missing, then just as in the Design Spiral, go back to the previous points and solve the issue.

At the final phase, an interior design project is complete. The design result is discussed with the commissioning party. If necessary, changes are made taking into account the phases described above.

To describe the application of this framework, the authors took Project Canvas as a structure. Project Canvas is a tool that enhances communication in project groups and provides a simplified project overview. Project Canvas is based on well-known project methodologies, including PRINCE2 (*Projects IN Controlled Environments*), PMI (Project Management Institute), which is a non-profit participation association, the project management certification and standards organization) and *Scrum* (this methodology consists of five values: commitment, courage, focus, openness, and respect. It aims to develop, supply and maintain complex products through cooperation, responsibility and repeated progress). Project Canva consists of 12 elements that provide a complete overview of a project.

Based on all these elements, the authors have drawn up phases that should be followed when designing the interior with biomimicry techniques:

The objective: a sustainable interior design. The project is needed to improve the quality of life of a society. The intention is to help to develop high-quality long-term solutions to the daily life of a society according to nature. An interior design is created that is close to natural processes, using all available materials

and products created on the basis of biomimicry techniques.

Visual arc – a practical side of a biomass, the design of an interior design, the use of Design Spiral and the Principles of Life. The part of the project study on the available resources for building interiors on the domestic market with the possibility of exporting to foreign countries. Outside the borders, just in an interior design, there is an existing building design where an interior design is designed. The project should cover the local market as well as the field of the research and the technology.

Benchmarks for success: sustainable materials have been used in the design of the interior, including biodiversity methods in order to make the project successful reaching a potential audience for which the project will be up-to-date. The benefits of the project are public education and environmental development. The benefits are measured on the basis of the results achieved, i.e. what service positions in this sector will be, how many consumers will be able to attract.

1. Criterion: the number of projects developed
2. Criterion: a sustainable product
3. Criterion: a project meets *visual arc* standards
4. Criterion: the number of audiences reached

Outcome: a sustainable interior design product using biomimicry techniques.

The next phase is to identify people, both team and stakeholders and users. In this case, the team may consist of a company's employees, a materials' specialist, a biologist (who knows the natural processes) and a designer. If necessary, additional specialists can be attracted to make the project even more successful than it is. The stakeholders are a company's management & owners and local companies that produce products from local materials. In this case, the user will be a customer who is interested in a sustainable design as well as role-playing providers, the companies that work and offer products produced from local materials or companies producing locally sourced materials.

The third phase is to test the environment. It includes resources, constraints and risks. The resources needed should be identified at the

outset. One of the most important resources in this project is certainly time. In order to fully develop an interior design based on biomimicry methods, it should be noted that the necessary materials and collaborative partners working with sustainable products could take time. Other resources are hardware for a design, the necessary knowledge of products and materials (Table 7).

**Table 7. Resources for a Framework Application**

Material resources	Intangible resources
Hardware	Time
Computer programs	Identification of products' producers
Survey tools	Identification of materials' manufacturers
Color passport	Partners
Samples of materials	Understanding biomimicry
Financial resources	Human resources and their knowledge

Source: created by authors

Restrictions or barriers to such a project would include the non-existent resources or materials needed to design a sustainable design. As well as a lack of knowledge. Certainly, risks are: a lack of knowledge in biomimicry and the introduction of a new method in the course of the design. See risks in Fig.4.

The authors looked at the potential risks of creating such a design. Table 4 legend: R1 - No products; R2 - No materials; R3 – a High cost; R4 - No demand; R5 - Order not in progress; R6 – Customers' frustration with a final result; R7 - Material costs increased; R8 – a lack of knowledge; R9 – a Service price; R10 – a Project's price adoption; R11 – a lack of technology; R12 – a lack of knowledge.

The design of biomimicry is a new method, then a number of risks are allowed, which can have a significant impact on the design of such a project.

	Very low probability	Low probability	Average probability	High probability	Very likely
Very high impact			R7	R5	
High impact	R1	R2, R6	R12, R4	R8	
Medium impact		R10	R11, R9	R3	
Minor impacts					
Very low impact					

**Fig.4. Risks' Matrix.**

Source: created by authors

**Conclusions.** The authors of this article have proposed the framework for biomimicry application in an interior design product development. Key milestones for the development of the framework are milestones for the biomimicry purpose design process for an interior design by changing the Biomimicry Design Spiral phase sequence and the adaptation of design activities for an interior design product development.

The most important milestone is a design, because at this point, activities are a number of which biomimicry methods should be followed. These are natural lights identification, planting, forecasting of local materials, and scheduling the functionality. On the basis of the development of the framework, the authors created and described an operational phase-based interior design system for sustainable design. The important phase of an interior design is biomimicry based.

This phase is based on biological sections of the design of the biomimics, the sequence of which is changed by adjusting the design principles of the interior. In an interior design, biomimicry as a method is not widely represented by the use of this phase system, an interior designer gets a more sustainable design for this project. Using local finishing materials and products, bringing plants into space, identifying natural light and using it in a design and creating biomass interiors when designing a functional design. However, for an interior design to be further created in biomimicry, it would be necessary to investigate further the second level of biomass, which is a simulation of the body, in which case the body is human and this environment is a room.

#### **Future Research Directions.**

- (1) Validate the framework in a practical application;
- (2) Collect and analyze case studies about different approaches in an interior design product development and biomimicry aspects;
- (3) Conduct a survey for enterprises and

experts to evaluate this framework and an overall biomimicry application situation and its potential in an interior design.

Mimicked structures of nature sometimes are very complex. This leads to the search of the tools that could provide that assistance. One of such tools are different computer provided possibilities, because it is an accurate tool for the simulation and computing, as a result designer can imitate different nature's models in spite of its complexity [27]. In future the authors could research computer tools that could be used in each stage of suggested frameworks.

Biomimicry for 3D concrete printing [28] is a new and interesting research object. Future research directions could test how the created framework could work in this context.

Researchers also explore biomimicry innovation as the way to support the infrastructure sustainability and resilience [29-31], it should be researched does biomimicry always lead to more sustainable solutions in the end – it should be a multi-level and long-term research.

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