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# Integrating Bioarchitectural Approaches in the Design of Universities' Halls of Residence to Guarantee Students' Well-being

# دمج اتجاهات العمارة الحيوية في تصميم السكن الطلابي للجامعات لضمان رفاهة الطلاب

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**Abstract**

*Universities' halls of residence are integrated educational communities committed to providing safe and healthy environment for living-together students with different cultures, to encourage them develop their abilities and motivate them. The main factor that helps creating a built environment that achieves these goals is by confirming the harmonious relationship between occupants, built environment and nature. However, this was not the only reason that prompted the interest of today's architects to draw inspiration from nature's systems, but also the sustainability's focus on "automated" solutions. So came Bioarchitecture and its approaches as the answer to emphasize that harmonious relationship to guarantee occupants' well-being; subjectively or objectively. But to date, the vast majority of studies of bioarchitectural design, especially biophilic ones, have focused on the design of specific environments, with a lack of research on the benefits of bioarchitectural approaches in university environments. Proceeding from this and from the current state of the majority of public halls of residence in Egypt nowadays, the research presents a rehabilitation design proposal for Building (B) of the hall of residence of Alexandria University (Smouha), through the perspective of bioarchitectural approaches, a design that meets the parameters identified to guarantee students' comfort; psychological and physiological in its built environment. To conclude that bioarchitecture is a vital applicable aspect to today's designs whose different approaches offer endless* *solutions that suit different types of projects, whether those that have not yet been designed or those that are being rehabilitated.*

**Keywords**

*Universities' Halls of residence; Human well-being; Indoor Environmental Quality; Bioarchitecture.*

**الملخص:**

*تعد قاعات السكن الجامعية مجتمعات تعليمية متكاملة ملتزمة بتوفير بيئة آمنة وصحية للطلاب الذين يعيشون معًا من ثقافات مختلفة، ولتحفيزهم وتشجيعهم على تطوير قدراتهم. العامل الرئيسي الذي يساعد في إنشاء بيئة مبنية تحقق هذه الأهداف هو تأكيد العلاقة المتناغمة بين الشاغلين والبيئة المبنية والطبيعة. ولكن، لم يكن هذا هو السبب الوحيد الذي دفع اهتمام المهندسين المعماريين اليوم للاستلهام من أنظمة الطبيعة، ولكن أيضًا تركيز الاستدامة على الحلول "الآلية". لذلك جاءت العمارة الحيوية اتجاهاتها كإجابة للتأكيد على تلك العلاقة المتناغمة لضمان رفاهة شاغليها؛ الذاتية والغير ذاتية. ولكن حتى الآن، ركزت الغالبية العظمى من دراسات العمارة الحيوية، وخاصة البيوفيلية، على تصميم بيئات محددة، مع نقص في الدراسات حول فوائد الاستفادة من تطبيق اتجاهات المعمارية الحيوية في البيئات الجامعية. انطلاقا من هذا ومن الوضع الحالي لغالبية قاعات السكن الجامعية الحكومية في مصر في الوقت الحاضر، يقدم البحث مقترح تصميم لإعادة تأهيل للمبنى (ب) لقاعة السكن الخاصة بجامعة الإسكندرية (سموحة)، من منظور المناهج المعمارية الحيوية، تصميم يفي بالمعايير المحددة لضمان راحة الطلاب؛ نفسية وفسيولوجية في بيئتها المبنية. لاستنتاج أن العمارة الحيوية هي منظور حيوي قابل للتطبيق في تصميمات اليوم حيث تقدم اتجاهاتها المختلفة حلولًا لا نهائية تناسب أنواعًا مختلفة من المشاريع، سواء تلك التي يتم تصميمها من البداية أو تلك التي يتم إعادة تأهيلها.*

**الكلمات الافتتاحية:**

*قاعات السكن الجامعية؛ رفاهة الإنسان؛ جودة البيئة الداخلية؛ العمارة الحيوية.*

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## 1.INTRODUCTION:

### 1.1 THE VITAL ROLE OF UNIVERSITIES STUDENTS' ACCOMMODATIONS:

Universities aim to raise the educational and cultural level in the country through the quality of education and the services they provide. One of their most important services are their halls of residence, which provide students with a place to stay during their studies there starting a new stage in their lives. Globally, they are built with the aim of facilitating this transitional phase in students' lives. Otherwise, students far from their homes will find it extremely difficult to attend classes and adapt to their new environment.

University owned Halls of residence are the most common form of student housings. They are often intended for first-year students (The most common types of student accommodation, 2019), managed by the university and usually very close to its locations. The downside to this type of halls is that they tend to be frugal in terms of their facilities and interior design. Some of them may be suitable, but others need more care (The different types of student accommodation, 2018). Therefore, we now witness many major campaigns undertaken by institutions to improve the quality of their housing services to achieve the highest standards. These standards must take into account a set of basic considerations for student life such as social diversity, sustainability and concern for the environment, and this will be reflected in the students' shared life (Neuman. D. J., 2013).

### 1.2. THE IMPACT OF THE INTERIOR ARCHITECTURE OF THE HALLS OF RESIDENCES ON THE LIVES AND WELL-BEING OF STUDENTS:

Through the studies of researchers and universities on the impact of halls of residence's environment on students' learning experience and well-being for decades, it has been found that:

- It affects their behavior, development and academic performance (Lanasa & Alleman, 2007) (Araujo & Murray, 2010).
- It promotes unity and diversity among students.
- It helps provide an environment that stimulates intellectual development promote the social

integration by allowing the student to easily interact with their colleagues (Akinlolu& Simpeh,2018) .

Accordingly, the role of their interior architecture appears in order to guarantee the well-being of the students, as the elements of the interior architecture design can influence their behaviors, habits and feelings, and directly affects their physical and psychological health. Therefore, making health and well-being an explicit component of planning is critical (Lekić, O., et al., 2018).

While considering well-being in creating the interior architecture of halls of residences, architects should have in mind that students' ultimate well-being consists of two main parts; Subjective well-being and Objective well-being (Almusaed, A., et al., 2006), shown in **Figure 1**. Which means that designs have to go beyond optimizing individual parameters such as temperature and humidity- which, to some extent, can contribute to occupants' ultimate well-being, to more holistic approaches that take into account human happiness, flourishment and promoting behaviors (Steemers. K, 2015).

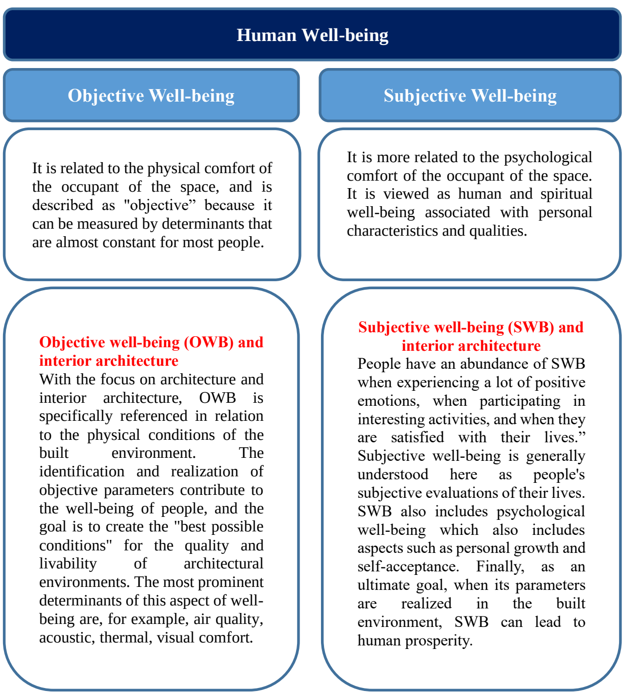



**Figure 1:** Comparison between students' objective and subjective well-being through the lens of interior architecture.
Adapted from: (Petermans & Pohlmeyer, 2014)

## 1.3. RELATIONSHIP BETWEEN STUDENTS' WELL-BEING AND INDOOR ENVIRONMENTAL QUALITY (IEQ):

As stated in ASHRAE Guidelines (2010), people spend about 80-90% of their time in built environments (EPA, 2000), research has also clearly demonstrated that IEQ problems of a building have a direct impact on the comfort, health, and productivity of building occupants (AlHorr, Y, et al. 2016). This means that these parameters of interior environmental quality have an impact on both objective and subjective well-being. Thus, improving buildings' indoor environmental quality (IEQ) of halls of residence is likely to have a positive impact on the ultimate well-being of their occupants; Students.

**Parameters of Indoor Environmental Quality (IEQ):** The parameters of IEQ include many elements that affect the comfort and well-being of design occupants, both physical and psychological, namely;

1. Indoor air quality
2. Thermal Comfort
3. Acoustic comfort
4. Visual comfort. among many other parameters

The next figure summarizes each element and its determinants (Indoor air quality, n.d.), (AlHorr, Y, et al., 2016), (Acoustic comfort, n.d.), (Visual

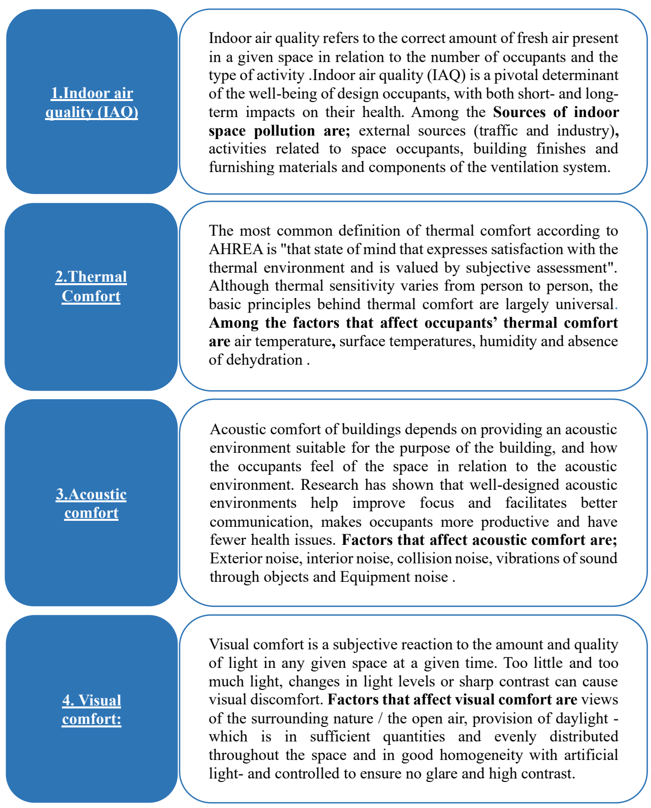



**Figure 2:** Parameters of indoor environmental quality (IEQ) in the built environments.

comfort, n.d.);

### 1.4. HUMAN WELL-BEING AS A CORE COMPONENT OF NOWADAYS SUSTAINABILITY APPROACHES:

For a long time, the focus of sustainability was limited to purely technical factors in terms of saving energy and reducing dependence on electricity and others, with no focus on the human aspect. However, taking into account the human aspect in architecture and interior architecture has become a priority nowadays. Therefore, new building regulations, legislation, and green building guidelines seek to improve the previous notion of sustainability and integrate psychological, cultural and social dimensions, in order to achieve the ultimate well-being of humans (ASHRAE, 2004). In order to achieve long-term sustainability and to contribute to the well-being; psychological and physiological of the human aspect, it is necessary to restore and enhance the positive relationship of man with nature in the built environment. Here comes the role of Bioarchitecture, as a basis for innovation, which has the ability to contribute to the creation of more sustainable and regenerative built environments (Pedersen Zari, M., & Hecht, K. 2020). The concept of simulation is no longer limited to the symbolic metaphors of nature without the core aspect of design, and with the development of science and the age of digital revolution, attention to nature has become more profound at different levels, represented in Bioarchitecure.

### 1.5. BIO-ARCHITECTURAL APPROACHES AS THE KEY TO HEALTH AND WELL-BEING OF BUILT ENVIRONMENTS' OCCUPANTS:

#### 1.5.1 WHAT IS BIOARCHITECTURE:

Bioarchitecture is a multi-scale approach to translating the solutions and opportunities offered by nature into solving global human problems. It is an architecture that integrates biology- inspired design into all parts of the work at all scales (Ripley & Bhushan, 2016), which provides innovative ideas and solution that cannot be generated by conventional engineering (Webb, M., 2021). It expresses a strong alliance between designer and nature, and the awareness that we all share a much greater dimension. What critically distinguish natural systems from many other man-made systems is that natural selection affirms the wisdom of the survival strategies that living organisms evolved to adapt to a wide range of environments, over the course of approximately 3.8 billion years (Bernett, 2015). Furthermore, nature aims to improve, not to increase, using the minimum materials and energy required for optimal performance (Amer, N., 2019). They form their structural forms based on their functional requirements, resulting in efficient and multifunctional systems to meet the performance requirements of every living organism. (Chen., et al., 2016). Therefore, Bioarchitecture is often described as a tool for increasing the sustainability of the built environment (Anous, I. H. I., 2015).

#### 1.5.2 APPROACHES OF BIOARCHITECTURE:

Bioarchitecture takes many forms and approaches, and each has its advantages (Bernett,A. 2015). Although the terms of these approaches are used interchangeably in recent research, there is a fine line between them. Below we discuss these approaches, and what distinguishes them from each other;

##### 1.5.2.1 BIOMIMICRY:

The ultimate goal of biomimicry is to extract design principles from biology and use them as a catalyst for thinking. Biomimicry produces adaptive, multifunctional and generally zero waste solutions. In the game of Biomimicry, Biologists are the main players, however, the role of the designer remains vital, as well. (Kennedy. et al., 2015)

Among the distinctive models of biomimicry, there are models that simulate the adaptive behavior of nature, as in the design of Flectofin® (Patent: Knippers et al., 2011). Others mimic the nature's production of energy; like the "Electric Life" that "Teresa van Dongen" created (Hitti,N. 2019) and the TU Lighthouse Leafroof 3 Project (Leaf roof, n.d.). Biomimicry has also produced models that mimic nature's minimal consumption of energy, such in the Mick pearce's design of the CH2 Council House in Australia, and the design of Sage Glass (AskNature Team, 2016), which simulates passive pigmentation found in many species of lizards and passive thermoregulation found in different hereditary kingdoms. Additionally, in terms of nature's ability to improve health and well-being, comes the design of PureBond® technology (AskNature Team, 2016) and the IKEA's Gunrid curtain design (Pownall, A. 2019). Last but not least, the simulation of natural systems' thermoregulation, in Hygroscopic structures and Homeostatic Facade Systems.

**1.5.2.2 BIOMORPHISM:**

An approach of Bioarchitecture that mimics natural shapes and patterns. It is often criticized for not adhering to biological principles, resulting in designs that do not necessarily perform better or are sustainable. However, the psychological aesthetic effects of natural forms should not be overlooked. A distinctive example of this approach is the design of the Great Room, the interior office space of the SC Johnson and Son Administration Building, designed by Frank Lloyd Wright. The design, reportedly improved the performance of company office operations between 15% to 25% (Bernett, A. 2015). Besides, the design proposal for Helsinki's new Guggenheim Museum in Finland with its dramatic structure that has been designed to mimic the waves of the waters by the harbor, which sits next to the design site (Walker, C. 2014).

**1.5.2.3 BIOPHILIA:**

The word "Biophilia" comes from Greek roots meaning "love of life", to describe the innate tendency of human beings towards nature, landscapes, and other living creatures (Browning. et al., 2014). Biophilia – just like air quality, thermal and acoustic comfort - is an important determinant of Indoor Environmental Quality, as it emphasizes the dimension of human health and well-being, by trying to find a solution to the problem of separation between human needs and the efficiency of building performance (Ismail. O.M.S, 2017). More recently, biophilic design is supported as a complementary strategy for addressing workplace stress, student performance, patient recovery, community cohesion and other familiar challenges to health and general well-being (Browning. et al., 2014).

**PATTERNS OF BIOPHILIC DESIGN:**

Biophilic design has been set to 14 Patterns which provide a framework for understanding and enabling the thoughtful incorporation of a rich variety of strategies in the design of the built environment (Browning. et al., 2014), illustrated in Figure 3.

Among the projects that successfully embodies Biophilic design is the Parkroyal On Pickering Hotel and Spa in Singapore (El Messelmani. A, 2018) and Foster + Partners' proposal of the Magdi Yacoub Global Heart Centre Cairo hospital in Egypt (Crook. L, 2020).

| | |
|---|---|
| **Patterns of Biophilic Design** | **(1) Nature in the Space:**<br>Nature in space deals with the direct and physical presence of nature in space; by creating meaningful and direct connections with natural elements, such as plant life, water, and animals, as well as breezes, sounds, smells, and other natural elements. Nature in space includes seven biophilic design patterns:<br>1.Visual connection with nature<br>2.Non-visual connection with nature<br>3.Non-Rhythmic sensory stimuli<br>4.Thermal & Airflow variability<br>5.presence of water<br>6.Dynamic &Diffuse light<br>7. Connection with diffuse light |
| | **(2) Natural Analogues:**<br>Natural analogous patterns deal with the existence of inanimate and indirect elements of nature; materials, colors, shapes and patterns found in nature, which can be implemented in the design of the built environment. It includes 3 biophilic design styles;<br>8.Biomorphic forms &patterns<br>9.Material connection with nature<br>10.Complexity & Order |
| | **(3) Nature of the Space**<br>Nature of the space Patterns deals with spatial formations in nature, and this includes our innate desire to be able to see beyond our immediate surroundings, our fascination with little danger or the unknown.<br>11.Prospect<br>12.Refuge<br>13.Mystery<br>14.Risk |

**Figure 3**: 14 Patterns of biophilic design

**1.5.2.4 BIOTECHNOLOGY:**

According to the United Nations Convention on Biological Diversity (as part of the United Nations Environment Program), Biotechnology means; *Any technological application that uses biological systems, living organisms, or their derivatives, to make or modify materials or processes for use".* In other words, Biotechnology is the use of life forms to develop the materials that humanity needs, whether from simulating simple techniques based in natural processes, to advanced genetic modifications, which allow to replicate desired characteristics in species (Montana-Hoyos & Fiorentino, 2016). It is one of the fastest growing industries in the world which requires knowledge of both biological and engineering principles. Its urgency of need comes from the environmental threat associated with the production of conventional materials that deprive non-renewable raw materials annually, the waste production and the fact that, since 1930, more than 100,000 new chemical compounds have been developed with no enough information regarding the health evaluation of 95% of their chemicals (Torgala & Labrincha, 2013). According to (Imani, M., et al., 2018), biomaterials are classified into main categories, as follows;

1. **Bio-Inspired Materials for Natural Recycling**, which includes

**A. Bioplastics:**

Bioplastics are of natural origin (plants or microorganisms) and are made, at least in part, from renewable biological raw materials, in order to facilitate the biodegradation process. Some of their notable examples is the bioplastic Dutch designers Eric Klarenbeek and Maartje Dros have created from algae, which could completely replace synthetic plastic - made from fossil fuels - over time (Morris. A, 2017), and the bioplastic Thomas Vailly made only from sunflower crop waste (Hitti. H, 2019).

**B. Biocomposites:**

Biocomposites are made from various sources such as plants or animals, and are made up of a mixture of either plastic with reinforced natural fibers or wood, as well. Such as the Hempcrete, which is an animal composite material made of hemp and lime, used as a building and lightweight insulation material because of its distinctive thermal conductivity (Imani, M., et al., 2018) besides air purification and moisture regulation, ensuring a healthy living environment (Hempcrete, 2020). Another application is the bio-brick a researcher at the University of Colorado Boulder created using genetically modified cyanobacteria. The production of this bio-building material requires less energy than the production of ordinary bricks, sequestering carbon dioxide instead of increasing its proportion in the environment (Srubar. W, 2020).

2. **Bio-Inspired Materials Imitating Organisms' Micro/Macrostructure or Patterns**, which includes

**A. Materials with Load-Bearing Behavior: Imitating Organisms' Micro/Macro structure:**

The micro and macrostructures of natural organisms have inspired researchers to design biomaterials with great load tolerance. For instance, the Chitosan, which is an organic chemical compound produced by processing chitin in shells of oysters and crustaceans. It is a raw material characterized by permeability, hardness, bearing loads such as bone, anti-bacterial, and the easy adaptation to different formations (Al-Akaby. E., 2017). Moreover, the experiment of using an active tissue microbiome of a bacterium called *Sporosarcina Pasteurii* to calcify knitting into architectural design materials (Hitti. N, 2019).

**B. Materials with Thermal Behavior: Imitating Organisms' Micro/Macro structure:**

The structure of the palm cells, in addition to their ability to withstand loads and pressure resistance properties, inspired the design of plastics and paperboard to serve the purposes of thermal regulation in buildings. The adsorption and adaptive performance of tree bark material, as well, were used to design a smart glass with a cooling layer adaptable to the building envelope, which regulate heat gain (Imani. et al., 2018).

3. **Bio-Inspired Materials Imitating Organisms' Functions**, which includes

**A. Materials with Intelligent Response Mechanism,** such as bio-concrete, which was designed by a team of researchers at the University of "Delft" in the Netherlands, by adding Bacteria to the traditional mixture to create a calcareous substance that is able to fill cracks in the stone material. The biological healing process depends on biomineralization (Di Salvo. S., 2018). Moreover, The Neredi Medmed Matter Group at MIT injected liquid melanin- extracted from bird feathers and squid ink into intricate channels inside transparent, 3D-printed acrylic bricks, to be used as a bio-skin for buildings (Aouf. R. S., 2019) benefiting from the function of the skin pigment; Melanin, of protecting humans from the sun's UV rays and protecting microorganisms from high temperatures, chemical pressures, and biochemical threats, in architecture.

**B. Smart Materials with Vibration Resistance:** Biomaterials take advantage of natural structures that are light in nature and use energy dissipation strategies to protect the entire structure from total collapse (Imani. et al.,2018).

4. **Bio-Inspired Materials Imitating Biological Processes:**

To mimic "growth" as a natural biological process is still so persistent that it cannot be compared even with what is found in nature. However, some designers have succeeded in taking advantage of controlling the growth of some organisms to manufacture biomaterials. Protocell Architecture is one of the most prominent research projects (Al-Akaby. E., 2017), Protocell technology was suggested in studies concerning the future of the historic city of Venice in Italy, to save its foundations from tidal changes. By planting experimentally developed dynamic droplets, designed to move away from light while in the water, move towards the wooden city foundations, use dissolved minerals and carbon dioxide in the water, to gradually producing a type of "Biocrete" which accumulates around the foundations. This distributes the city's weight over a wider base so that it does not sink into the soft soil of the delta on which it was founded (Armstrong. R., 2014).

**1.6. INTEGRATION OF BIOARCHITECTURAL APPROACHES IN THE DESIGN OF UNIVERSITIES' HALLS OF RESIDENCES:**

Based on what the research discussed about the effect of the halls of residences on students' lives and well-being, and the approaches of bioarchitecture, the integration of environmental design elements in universities spaces has its positive outcomes represented in:

i. Supporting the physical and psychological comfort and well-being of students, creating healthy environments that reduce stress, and promote creativity and cognitive development.
ii. Creating college environments that incorporate design elements associated with nature can increase restorative qualities of the environment, helping students focus on their learning and increase their productivity (Peters & D'Penna, 2020).
iii. The guarantee of providing a clean environment with proper indoor environmental quality.
iv. Less psychological pressure for the student, and an environment that stimulates the intellectual development of students.
v. Supporting students' living experience by helping develop and maintain a healthy student culture on campus; As well as providing a community environment.

And in the context of COVID-19, there is an urgent need to focus more on the role of the built environment on our health and well-being.

**2. METHODOLOGY:**

Proceeding from the literature review, and the fact that the majority of public residence halls in Egypt nowadays are not at the required level, as their built environment cannot guarantee the quality of life needed for students, the research studies the rehabilitation of the interior architecture of the existing Building (B) of the Alexandria University Hall of residence (Smouha) in Egypt, through the lens of bioarchitecture. According to the main objective of the design proposal, which is to upgrade the residence from its current state to a built environment that guarantee the ultimate well-being for students and emphasizes the interdependence and harmony between the built environment and nature, the methodology first determined the parameters of objective well-being and subjective well-being to be implemented in a harmonious way in the modified built environment of this residence, shown in **Figure 4.**

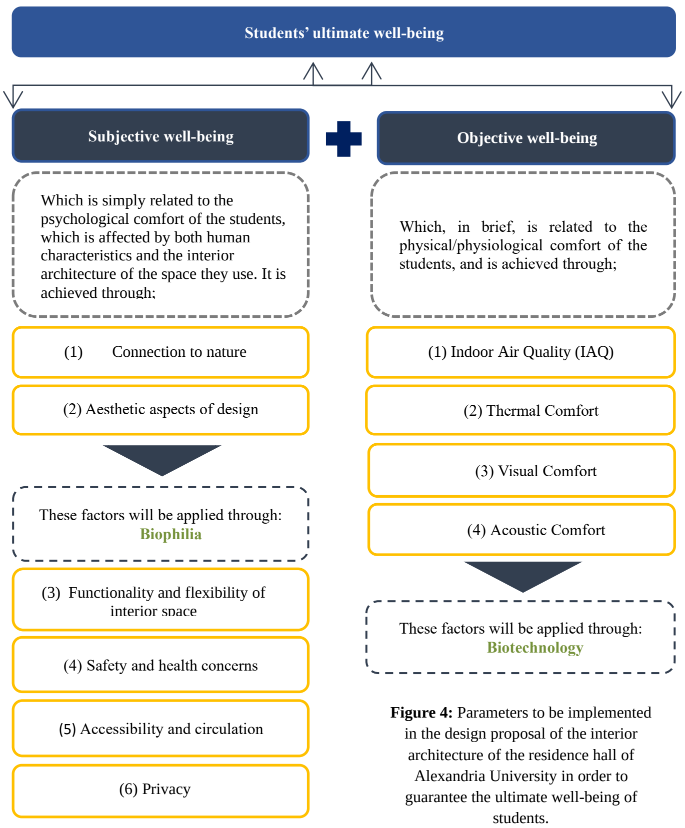



**Figure 4:** Parameters to be implemented in the design proposal of the interior architecture of the residence hall of Alexandria University in order to guarantee the ultimate well-being of students.

In order to apply these parameters in the rehabilitaion design, the methodology follows the following steps illustrated in Figure 5.

**(1) Re-distribution of the spaces of the ground floor and first floor of building (B)**

This step aims to reach a distribution of interior spaces that achieves a positive impact on its occupants, in terms of flexibility of circulation and functionality, and to create spaces that emphasize social interaction, by:
a. The analysis of the drawbacks of the current state of both ground floor and first floor of Building (B) with field visit.
b. The design of new floorplans of the ground and first floor of Building (b), addressing the existing problems in the current situation.

**(2) New design of the interior architecture of selected zones of the ground and first floors**

Three zones have been chosen to be redesigned:

- Reception area
- Student bedroom
- Common room

This step aims to achieve both physical and psychological comfort for their occupants through:
a. The design of the interior architecture of specific zones whose floorplans have been reimagined.
b. The use of sustainable bio-materials that contribute to indoor environmental quality and ensure connection to nature.

**Figure 5:** Steps of the design plan of the rehabilitation of Building (B) of the halls of residence of Alexandria University

## 2.1. ABOUT THE HALL OF RESIDENCE OF ALEXANDRIA UNIVERSITY (SMOUHA):

The accommodation is located in Ismail Serry Street in Smouha. It was commissioned in 1975. The total capacity of the residence is 2600 students. And it consists of 4 buildings (A, B, C, D), each building consists of 7 floors, each floor with three perpendicular wings in the form of the letter "T". **Figure 6 & 7.**

**Figure 6:** The location of the residence hall of Alexandria University (Smouha). Source: Google Maps

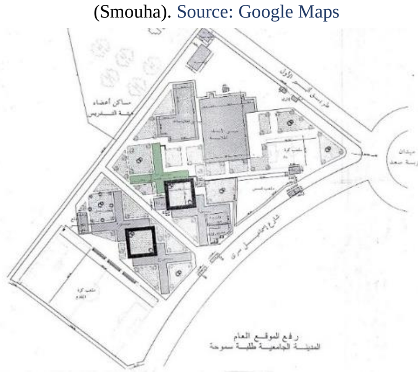


**Figure 7:** Distribution of the buildings of the hall of residence of Alexandria University. Building (B) colored in Green.
Used with permission from the Engineering administrative office of Alexandria University.

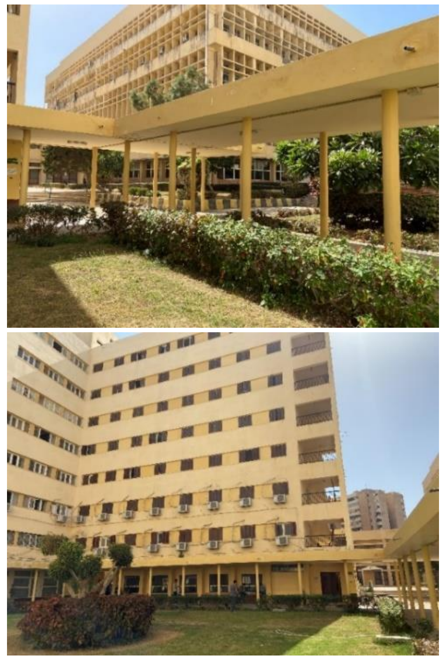


**Figure 8:** Exterior of building (B) of the residence.
"Taken by Author"

## 2.2. RE-DISTRIBUTION OF THE SPACES OF THE GROUND FLOOR AND FIRST FLOOR OF BUILDING (B):

### 2.2.1. Analysis of the current state of both Ground floor and First floor of Building (B):

The author visited Building (B) of the hall of residence of Alexandria University, to study its current state regarding the functionality of circulation, distribution of interior spaces and accessibility, …etc., based on the fact that all these elements effect the subjective well-being of the building's users and occupants. The ground floor consists of the residence's head office and administration offices of the hall of residence of Alexandria University. The typical floors consist mainly of students' rooms and small common room, in addition to service spaces. The authors documented the visit through pictures, shown in **Figures 9 & 10**.

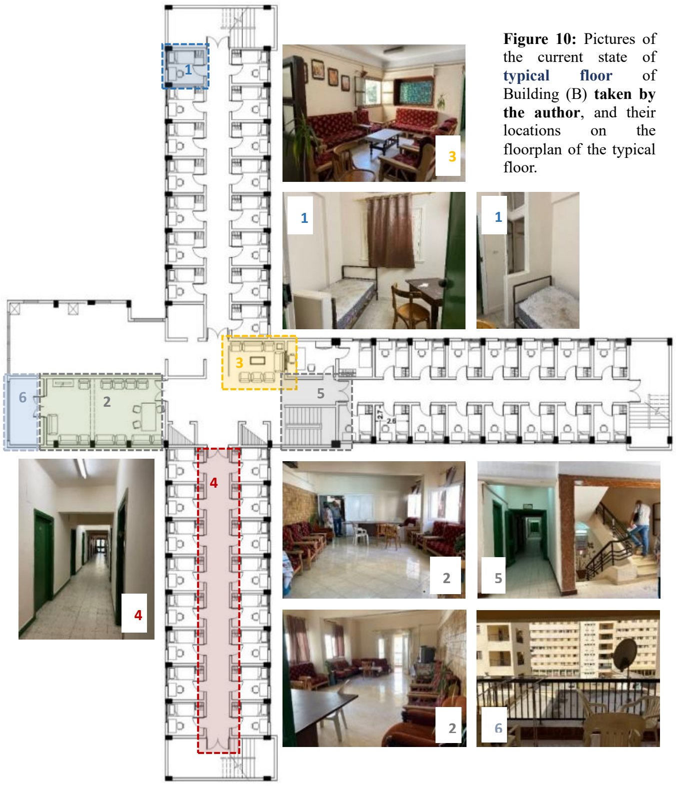


**Figure 10:** Pictures of the current state of **typical floor** of Building (B) **taken by the author**, and their locations on the floorplan of the typical floor.

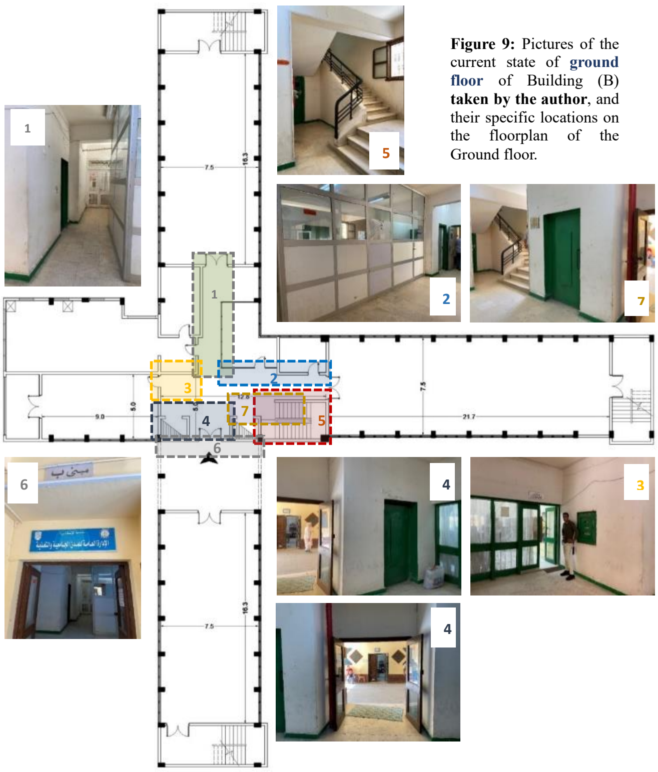


**Figure 9:** Pictures of the current state of **ground floor** of Building (B) **taken by the author**, and their specific locations on the floorplan of the Ground floor.

**Design deficiencies concluded from the analysis of the current state of the ground and typical floors of Building (B):**

- Absence of identity and design characteristics of the interior spaces.
- Absence of Biophilic design elements.
- Complete separation from the surrounding nature and lack of views.
- No enough sunlight into the interior space.
- There is no specific zone in the reception area to welcome and direct visitors.
- Discomfortable and dull design of the student's bedroom.
- Not making optimal use of the common room, despite it being considered a vital space for students' social interaction.

Accordingly, the design doesn't contribute to the psychological comfort for its occupants and visitors.

### 2.2.2. New floorplans design of the Ground and First floor of Building (B), addressing the existing problems in the current situation:

Based on the observation of the Ground and First floor of Building (B) through the field visit, the analysis of their functionality and listing the drawbacks, new designs for the floorplan of both Ground and First floor have been set to address these deficiencies, as shown in **Figures 11& 12**.

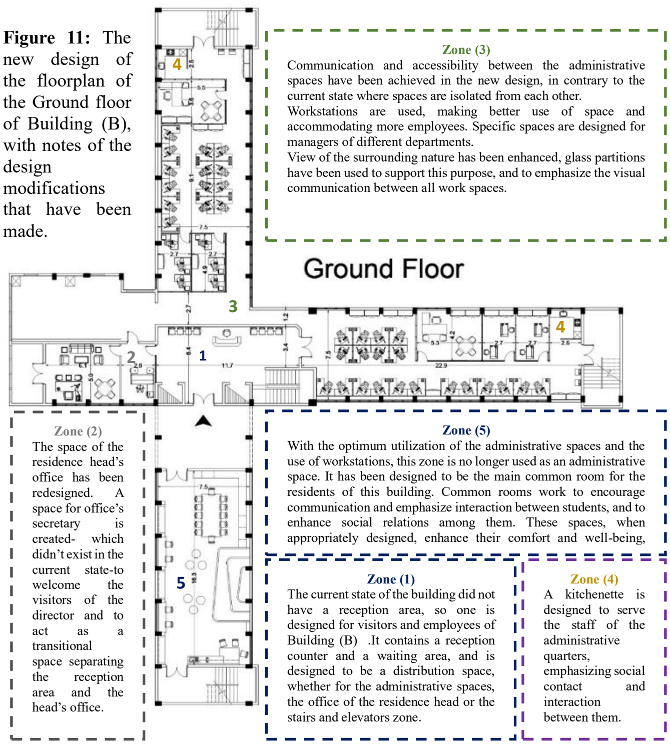



**Figure 11:** The new design of the floorplan of the Ground floor of Building (B), with notes of the design modifications that have been made.

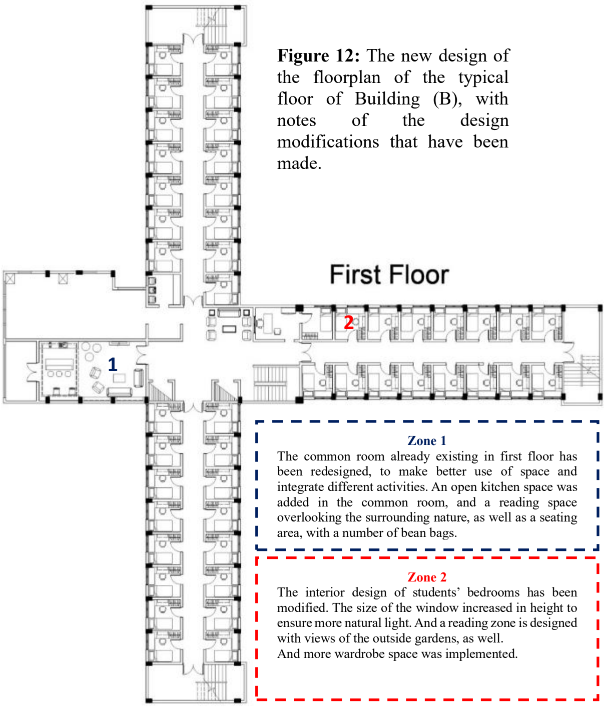



**Figure 12:** The new design of the floorplan of the typical floor of Building (B), with notes of the design modifications that have been made.

## 2.3 NEW DESIGN OF THE INTERIOR ARCHITECTURE OF SELECTED ZONES OF THE GROUND AND FIRST FLOORS:

The new interior architecture of these zones is created assuring the main objectives of the rehabilitation; to creates environments that are functional and healthy, and promote positive feelings for students, from the perspective of the approaches of Bioarchitecture; Biophilia and biotechnology.

### 2.3.1.THE DESIGN OF THE INTERIOR ARCHITECTURE OF SPECIFIC SPACES WHOSE FLOORPLANS HAVE BEEN REIMAGINED.

After addressing the modifications that were made to the design of the floorplans and zones distribution of Ground and Typical floor, in this stage the research proposes a new design for the interior architecture of three zones in Building (B);

(1) Reception area.
(2) Student's bedroom
(3) Common Room

#### (1) PROPOSED DESIGN OF THE RECEPTION AREA:

The new design has been reimagined with the purpose of leaving a positive impact on its users, both physiologically and psychologically. In this design proposal, the administrative spaces have been separated from the entry and reception area, to create privacy for the employees and not to force them to pass by the reception area in order to reach another administrative area. A proper reception area was designed to include a reception counter and two waiting areas, which did not exist in the current state. The design took into account the patterns of Biophilic design, such as the existence of vegetation, use of natural materials like wood, and the formation of the tiles in the background of the counter. Moreover, the prominent point that was taken into account in this area is to ensure the biggest amount of natural lighting into the interior space. In the existing design, this area did not have sufficient natural lighting, so larger openings were made around the entrance door and covered with glass, which guaranteed more sun light into the reception area. Furthermore, the elevator area was distinguished by the color and vertical lighting lines, for more functionality and accessibility. For greater illumination and to emphasize connection with the surrounding nature, the staircase area has been redesigned, replacing the small window at the staircase, into a glass wall combined with wood panels.

All these factors contributed to the design of a welcoming and functional reception area for its visitors and users. The following figures show in detail the modifications that have been proposed for the interior architecture of the Reception Area, in comparison to the current state of the same zones.


**Figure 13:** (Left) The design proposal for the reception area of Building (B).
**Figure 14:** (Below) Picture of the same zone of the reception area in the current state. **(Taken by author).**


**Figure 15: (Right)** Design proposal for the entrance in the reception area for Building (B) .
**Figure 16:** (Below)The entrance of the reception area in the current state. **(Taken by author)**

## (2) PROPOSED DESIGN FOR THE STUDENT'S BEDROOM:

The existing layout of the room was gloomy and with no positive impact on students' well-being, hence their productivity and focus. The main focus of the proposed design for the student's room was to create a design that is cheerful, positive, and that encourage concentration. Thus, the interior space of the room is redistributed, **Figures 17 &18**. The window area is enlarged in order to ensure the biggest amount of natural light. A reading and sitting zone by the window are designed to emphasize the connection with the surrounding view of the building. Minimalistic approach was chosen for the interior design. The design takes into account the use of natural materials such as wood in various design parameters. The following figures show in detail the modifications that have been proposed for the interior architecture of the room, in comparison to the current state of the same one.

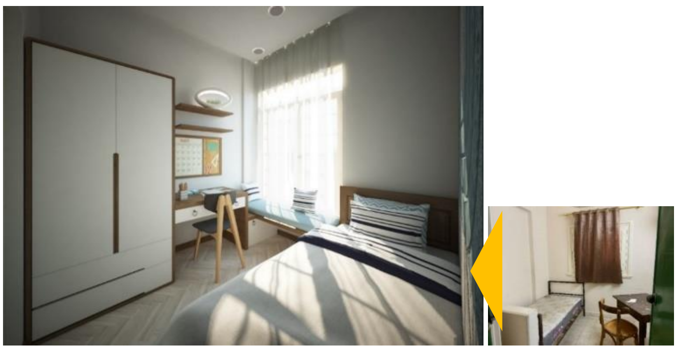


**Figure 17: (Below)** Picture of the student's room in the first floor of Building (B) in its current state. (Taken by author).
**Figure 18: (Left) The design proposed for the student's room.)** It shows the proposed minimalistic design for the room, the enlarged space for closet and reading seat by the enlarged window.

## (3) PROPOSED DESIGN FOR THE MAIN COMMON ROOM:

In the new distributions of zones in the floorplan for the Ground floor of Building (B), it was suggested to allocate a main common room, to be a gathering space for all students living in the same building, which would encourage social communication and interaction among them, **Figure 20**.

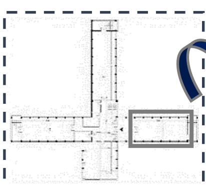


**Figure 19:** The suggested zone for the common room in the new Ground floor design of Building (B).

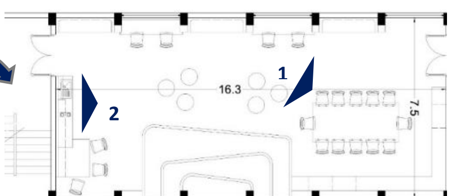



**Figure 20:** The floorplan design for the main common room in its suggested zone on the Ground floor of Building (B).

The main objective of this design is to create an environment that affect students' psychology and attention positively, a space that can welcome as many students as possible to share various activities. Biophilic Design is presented through design parameters, such as: connection to nature via windows views, abducent natural lighting which enhances students' productivity, besides using natural materials. An open kitchen area is designed as well. For a better use of the space, to welcome bigger number of students, vertical space was utilized by designing a bleacher seating. A reading zone is designed in the new Common Room, with different types of seating. The following figures show in detail the proposed design of the interior architecture of the main Common room.

**Figure 21:** Zone (1) of the proposed design for the Common Room

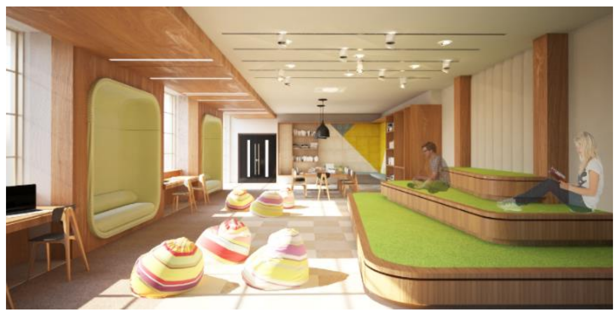
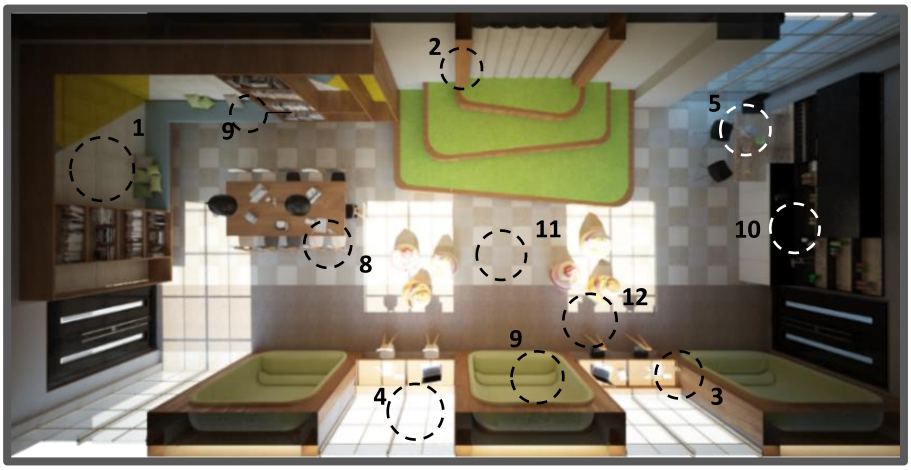


**Figure 22:** Zone (2) of the proposed design for the Common Room

### 2.3.2. SELECTION OF BIOMATERIALS THAT CONTRIBUTE TO INDOOR ENVIRONMENTAL QUALITY AND ENSURE CONNECTION TO NATURE:

Next is an analysis of the biomaterials selected to be integrated in the proposed design for each of the reception area, the student's bedroom and the main common Room, to contribute - with the proposed floorplans and biophilic interior architectures of those spaces - in achieving the comfort and well-being; subjective and objective of the occupants of these zones. First, **Figure 23** illustrates where these materials are integrated in the 3 zones, then an analysis of these materials in **Table 1**.


Reception area




Common room.


Students' bedroom

**Figure 23:** Indications of the biomaterials chosen to achieve the IEQ" Interior Environment Quality" of the Reception, Students' bedroom and Common room.

| No. | Suggested Biomaterial | Properties of the material |
|---|---|---|
| 1 | BAUX acoustic panels and tiles | An environment-friendly, recyclable material containing wood and cement. Wood fibers provide excellent insulation, heat retention and sound absorption. Cement, a popular building material, is the adhesive that provides strength, moisture resistance, and fire protection. Thus, the material:<br>• Reduces noise and contributes to providing acoustic comfort in buildings.<br>• Absorbing moisture in the surrounding air, which contributes to comfort and health.<br>• It stores heat from the surrounding air and releases it when the air temperature drops, which contributes to lower energy costs, reduced environmental impact, and a stable and comfortable indoor climate.<br>• Fire-resistance. (*BAUX wood wool panels*.) |
| 2 | Biowood Composite timber | Biowood is a biocomposite of wood and plastic, a sustainable and eco-friendly alternative to natural wood.<br>Features of Biowood Composite Timber:<br>• Free from toxic chemicals, which ensure IEQ.<br>• Designed while retaining the look of natural wood.<br>• Lightweight.<br>• Water-resistant (less than 0.05% water absorption) and fire-resistant.<br>• Since it does not absorb water, there is no chance of mold and termites.<br>• Low maintenance.<br>Using cladding of a biomaterial alternative to wood, mimicking the shape of natural wood, helps emphasize connection to nature and implant a sense of comfort for students (Biowood & It's brilliant benefits, 2020). |
| 3 | PureBond® technology | Plywood adhesive technology that is formaldehyde-free. It mimics the natural adhesion strength of Blue Mussel. The removal of formaldehyde - in the process of its manufacture - makes it a safe product due to the health concerns that arise during the production of formaldehyde .It can contribute to the indoor air quality. (AskNature Team, 2016) |
| 4 | Electrochromic Glass "Sage glass" | It is used for windows and openings in the reception area, student's room and common room. It is a glass tinted automatically or on demand to control sunlight, without blinds, which maintains contact with the outdoors and reduces energy consumption.<br>Electronic 'photovoltaic' glass enhances indoor daylight, provides visual comfort, and keeps students in touch with the surrounding nature, making them happier, healthier and more focused.<br>The main inspiration for this technology is passive pigmentation found in many species of lizards in nature. (How dynamic glass works, n.d,) |
| 5 | Sharklet™ | It draws inspiration from the shape and pattern of the dermal denticles of sharkskin. It is an adhesive surfactant used to control bacterial growth by 80%. It contains no chemicals. This film is adhered to multi-touch surfaces in the building to contributes to providing a healthy and clean environment for students and to help guarantee IEQ. (Adhesively-backed film, n.d.) |
| 6 | MOGU Flooring | This bio-based resilient tiles were used in the floors of specific spaces of the design proposal to satisfy the needs of everyday life both functionally and aesthetically and to |

| | | |
|---|---|---|
| | | establish harmonious relationship with the surrounding environment.<br>These floors are designed with the lowest possible environmental impact, and is 90% bio-based-such as corn crops, rice straw, spent coffee, discarded seaweed and clam shells. It replaces traditional industrial dyes, 100% plastic-free, safe and durable - and biodegradable as well. (Resilient floors, mogu) |
| 7 | Gunrid curtain, IKEA | The design proposed using an air-purifying curtain coated with a mineral-based surface that breaks down common pollutants when light shines through it, allowing users to purify the air in their own spaces. It works in a similar way to photosynthesis and help purify the air in the interior spaces. (Pownall. A., 2019) |
| 8 | Kuskoa Bi chair, by Iratzoki Lizaso | This chair is made of Bioplastic. Which have similar properties to traditional plastics, but are made from renewable, plant-based sources. It is a completely recyclable material and has a significant environmental advantage as it reduces greenhouse gas emissions.<br>The bioplastic used to manufacture the chair used in the design proposal is based on PLA (PolyLactic Acid), a biopolymer obtained from the transformation of starch. (kuskoa Bi, n.d) |
| 9 | GreenSheild Textile | This technology is a texture coating inspired by the surface of the nano-textured lotus leaf which is self-cleaning, but with a new dimension of adding oil resistance, fire resistance, and antimicrobial functions. This contributes to providing a healthy environment for students. (GreenShield fabric finish, 2016) |
| 10 | Bioplastic made of sunflower crop, by Thomas Vailly | This bioplastic is used for the counter top of the kitchen in the common room as an alternative to traditional plastics, it is made of sunflower crop waste. (Hitti, N., 2019) |
| 11 | i2 ™ Modular Carpet, InterfaceFLOR | For the floor of the Common room, this material was selected; carpets inspired by the harmonious rhythm of forest floors and riverbed stones. They are carpet tiles that feature random, non-directional pattern and color gradations.<br>i2™ Modular Carpet features:<br>○ Designs that can be installed in any order and orientation, which means less installation time and approximately 90% less waste than traditional carpeting.<br>○ Provides good sound absorption, ideal for places that require calm and concentration.<br>• Carbon neutral across the entire product life cycle which contributes to reducing global warming. (I2 carpet tiles, n.d) |
| 12 | TacTiles, InterfaceFLOR | TacTiles are used to fix i2 ™ Modular Carpet to the floor. It is inspired by the molecular force field that allows reptiles to magically stick to surfaces. They require no glue, no additional drying time, no VOCs and 90% less environmental impact than traditional carpet adhesives. Moreover, it is resistant to moisture and heat. (TacTiles, n.d.) |

**Table 1:** Analysis of the biomaterials suggested in the design proposal for rehabilitation of Reception area, Students' bedroom and Common room.

## 3. RESULTS:

Based on what has been presented in the proposed rehabilitation plan of building (B) of the hall of residence of Alexandria University (Smouha); starting from the modified distributions of the zones of the Ground and Typical floor, new biophilic designs for their interior architecture, to the integration of biomaterial that contribute to IEQ and in accordance to the objectives of the rehabilitation presented in **Figure 4**, the following diagram will analyze to what extent these objectives of the proposal were met, in order to contribute to achieving the well-being of the occupants of Building (B);


**Figure 24** :The elements of the proposed designs that contribute to the achievement of the well-being of students; objective and subjective.

## 4. DISCUSSION:

Through the steps the methodology this research followed, the proposed rehabilitation plan was able to meet all the parameters determined to ensure the well-being of the employees and students using Building (B) of the halls of residence of Alexandria University (Smouha). The bioarchitectural approaches integrated in this rehabilitation were limited to Biophilia and Biotechnology, the first to ensure occupants subjective well-being, and the last to guarantee IEQ, while both ensured occupants connection to nature. However, this limitation is because the proposal is applied to an already existing building which did put restrictions on the possible design options. Therefore, it is strongly advised to integrate bioarchitectural approaches in the first stages of design, this could have facilitated the application of many other approaches, such as; biomimetic strategies, whether in the building envelope, walls, claddings, etc. While we believe that these limitations haven't impacted the primary objectives of the study, future work could seek to study the integration of bioarchitectural approaches in the beginning of the buildings design. Furthermore, to use surveys to help assist the evaluation of students' satisfaction toward the built environments of their hall of residences.

## 5. CONCLUSION:

Despite the active role of universities' halls of residences on students in that transitional period of their lives, most public halls of residence do not elevate to the level required to be achieved with regard to the well-being and comfort of students. Furthermore, relying only on the automated sustainable approaches of energy saving and controlling the interior environment, and others, to achieve the students' objective well-being, is no longer sufficient. The human aspect and its subjective well-being have become an important element in the equation of students' satisfaction toward the built environment of their residences that cannot be ignored. Hence, Bioarchitecture and its approaches pave the way for integrating this aspect in the sustainable development of this type of buildings, as it was evidenced here in this research to rehabilitate Building (B) of the hall of residence of Alexandria University. As in the folds of its various approaches, it has strategies, techniques, materials and aesthetics that contribute to the comfort of students towards the quality of the environment around them; psychologically and physiologically.

However, integrating Bioarchitecture into the design of the halls of residences does not require radical changes to the design concept, and here comes the crucial first step for architects in this process, which is to choose the compatible bioarchitectural approaches for the condition of the building subject to the design and for those parameters determined to be achieved for the ultimate well-being of the students.

## CONTRIBUTION:

All authors contributed equally in the preparation of this manuscript.

## CONFLICT OF INTEREST:

The authors declare that they have no conflict of interest.

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