FULL LENGTH ARTICLE

Considering coexistence with nature in the environmental assessment of buildings

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Received 2 September 2015; revised 18 July 2016; accepted 9 August 2016

KEYWORDS
Coexistence with nature; Psychological needs; Interactive buildings; Building filters; Environmental Assessment Methods of Buildings

Abstract Green Architecture appeared to achieve what is beyond sustainability in buildings. It seeks besides maintaining the balanced environmental and building cycles to interact with the nature. Its definitions are always concerned by achieving the human psychological needs besides their physical ones. Nature in the Green Architecture is not only a party to avoid its negative effects and benefit its advantages, but it is also a party that buildings help their users to feel coexistence within. The Environmental Assessment Methods of Buildings appeared to set the principles of the optimum relation between the buildings and the environment, but, the current methods did not focus on the human psychological needs, and they included few and static assessment items for that, such as linking the users visually with their external environment through the openings. This item does not reflect an ideal relation in the Green Architecture, which should be beyond that direct and boring one. It was formerly difficult to achieve innovative relations between building users and their surroundings, but recently, there are enormous potentials to do so. Therefore, the research paper aimed to get out of the traditional borders of the environmental assessment of buildings, and focus on assessing the human psychological needs through the assessment methods by some proposed items, which help to achieve a human coexistence with nature. The proposed items may be considered an important step toward the Green Architecture, when considering the almost ignored human psychological needs within the most important tools used to encourage its application.

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Peer review under responsibility of Housing and Building National Research Center.

Production and hosting by Elsevier

Please cite this article in press as: A.K.M. Shamseldin, Considering coexistence with nature in the environmental assessment of buildings, HBRC Journal (2016), http://dx.doi.org/10.1016/j.hbrcj.2016.08.002.

Introduction

Green Architecture includes the psychological human needs besides his physical ones, and its buildings were always resembled as living creatures, not only zero sustainable masses [1,2]. Integrating the building users with their nature, protecting the nature, and protecting the users from the nature are three important issues in the Green Architecture. These three issues have conflict achievement possibilities, as the users’ integration with the nature can be achieved by influencing their senses when connecting the inner and outer spaces, while there is a
need to isolate the inner spaces for both protecting the nature – that can be achieved by minimizing the air conditioning devices – and protecting the users – that can be achieved by providing them the desired safety, privacy and physical comfort.

Many researches discussed the recent potentials of the interactive relations between the building and their environment. Krietemeyer et al. [3] discussed the opportunities of dynamic building envelope that can respond to occupant needs while meeting the energy demands of buildings. Boerstra et al. [4] presented the building envelope technologies that dynamically respond to internal stimuli, providing individual control over comfort and privacy that often lead to greater satisfaction. Torgal et al. [5] presented a method to evaluate the performance and to support product development of adaptive micro- and nanobased material and technologies integrated into buildings. Bluyssen [6] discussed the ways, tools and concepts have been developed to determine performance indicators and criteria for healthy and comfortable buildings, presenting the incomplete response relations and the untaken interactions into account. It was observed that the perception of positive stimuli is in general not considered, and there is a need for a different or at least an adapted approach toward evaluation of health and comfort of occupants in the indoor environment. On the other side, the Environmental Assessment Methods of Buildings rarely assessed achieving the human psychological needs. Almonte [7] showed that occupants of the Leadership in Energy and Environmental Design (LEED) certified buildings have equal satisfaction with the occupants of non-LEED rated buildings, and there is not a significant influence of LEED certification on occupant satisfaction with indoor environmental quality.

Achieving coexistence with nature is a comprehensive expression of different human psychological needs. These needs are not set properly in the current Environmental Assessment Methods of Buildings. The research paper aimed to change the traditional thought of achieving the human psychological needs using only the static openings, to introduce buildings to achieve coexistence with nature, as a group of filters of several connecting levels that help users to recognize and interact with their nature constantly in different ways, and to integrate the previous concept within the current Environmental Assessment Methods of Buildings. So, it first introduced the related human needs that are supposed to be improved, showing the current usual ways to achieve them. Then it presented the Environmental Assessment Methods of Buildings as the chosen tools to encourage the achievement of those needs. Then it spotted a light on the proposed different ways to achieve the previous needs continuously and controllably. And finally, it suggested including some assessment items to assess the relation between the users and their nature to exceed the buildings role from protecting the nature and the users to integrate both of them together continuously.

The human psychological needs related to the nature

The absence of any of the human psychological needs leads to mental balance losses and prevents human interaction and responsiveness with the environment. People desire a constant feel of connecting, interacting, and belonging to the nature, and those feelings could be summarized by achieving coexistence with nature. Variation is the main feature of nature, so, achieving coexistence cannot be done using fixed building features [8–11]. Separating people from their external environment to achieve safety or physical comfort affects human mental and intelligent status, and besides, it causes many other psychological problems such as idle, boredom and depression, it leads to eliminate distinction, innovation and creativity and deprives people of activating their imagination. Many scientists agreed that man needs to expose a constant change to maintain his intelligence level, he cannot develop his mind and thoughts unless he lives through successive variables, and the homogenized thinking does not happen without diversity of impressions and feelings. Besides the need of diverse views, man needs a sense of adventure that can be achieved by working in a changing sensory environment. Through the studies, it was noted that, if a single person was left in an isolated place he will suffer psychological impacts that appear in forms like anxiety and pain, which differs according to the used lighting color and intensity. In general, the diversity of lighting styles increases happiness, while the unamusing visual works and the lack of stimulation lead to boredom and monotony [11–14].

Influencing the human senses is a part of achieving coexistence with nature. Water, light and air are some environmental elements that can pass through the internal spaces with diverse characteristics to influence the senses in different ways [14–16]. It is noted that influencing the sight, hearing and touch senses is easier than the smell and taste senses; nevertheless, Frank Lloyd Wright in his famous falling water villa in Pennsylvania influenced all the senses, and the stone surface texture, the waterfall sound, the visual lighting effects, the scent of water and place, and the taste of salinity air are some feelings that can be sensed once entering that place [14].

Current usual ways to deal with buildings surroundings

For a long time, buildings were considered a shelter that should protect people from the external nature’ effects. In that context, the main building objectives were protection and safety. Therefore, buildings were designed to separate the users from their environment once they enter their internal spaces. An advantage of that vision is the ability of controlling the buildings’ internal environment easily, by providing the buildings with an internal climate of constant features, but when people enter their buildings; they feel they could be anywhere on earth, and they do not feel differences from one buildings’ position to another [13,14]. The resulted buildings help saving energy when using the technological systems to control the internal environment, as the separation between the external and the internal environment leads to the lowest exchange between them and the higher control opportunities. But, when people enter this type of buildings, they cross barriers between extremely two different sides, as these barriers are designed to keep the external environment outside and the internal environment inside. Buildings of this type block and isolate their users from their surroundings and deny their psychological needs [9,10].

With the passage of time and the appearance of various building capabilities, people looked forward achieving more objectives from their buildings, such as the ability of distinguishing and experiencing their external environment. The
evolution of materials and construction structures led to expand the buildings openings, helped people to connect their external environment visually through them, and helped the passage of air with its sensual effects when they are opened. Curtain walls were introduced to expand the connection between the interior and the exterior of the buildings, but their use led to inefficient energy consumption in many countries and places to control the internal environment that in return affects the nature, due to the need for an over needed technological systems in compare to not using them. The resulted buildings need to solve a number of problems such as the increased thermal loads and resulted glare, there are passive solutions that could be used to do so, but they cost more than the usual ones, such as using breezing walls in front of the glass walls to move the air between them to reduce the thermal loads, and using a double or triple glazing to provide thermal insulation. Even when accepting the exceeded cost or energy consumption, the openings and wall glass, which are considered the connection points between the internal and external environments, are connecting people with their surroundings in a direct way that could be boring over the time [11–13].

Green architecture

When the sick buildings expression appeared in the mid-seventies, it was referring to buildings that cause human dissatisfaction as a result of their effect on the human physical and psychological needs in the internal spaces, and they cause a number of health problems that may disappear when people get out of these buildings. Green Architecture was put to face that phenomenon. So, it is concerned with all different human needs in the internal spaces such as the physical, psychological, chemical and radiological [6,15,16]. Green Architecture is known as a highly efficient system that is compatible with its surroundings through self-control in the inputs and the outputs of the system, with minimal negative impacts on the environment and minimal energy and resource consumption over the building’s life cycle. Green Architecture definitions usually propose that buildings should seek and act like living creatures as much as possible, to be a part of the nature not only a non-harmful and sustainable mass. When green buildings are constructed, it is supposed to help their surrounding environment acting as before for the buildings existence or better. So, green buildings do not end the natural life in their sites to replace an artificial environment, and they are supposed to be integrated with the nature by a continuous interaction between them [6,17,18].

The relationship between the buildings and the environment can be summarized in reducing the negative effects of the external environment on the internal spaces, reducing the negative effect of the building construction, operation and demolition on the balanced ecosystem, besides, benefitting the nature to approve the building functions. Benefiting the nature may appear in many forms, as some of the natural characteristics help in operating buildings using clean and renewable energy, and some other characteristics help achieving a better life quality in the internal spaces by achieving thermal, acoustical and visual comfort. Another form to benefit the nature is achieving human psychological needs by feeling the natural variation and its effects on the users’ senses and emotions [15,16]. Green Architecture puts a set of principles to treat the imbalance in the relationship between the building and the environment. Thus, creating a healthy society, providing comfort and enjoyment, reducing stress from buildings on their users, increasing satisfaction and achieving integration with the surrounding environment are some of the Green Architecture principles along with many others. There are several forms to meet the human requirements associated with Green Architecture, including the continuous respond to the environmental changes. Buildings should act as a third skin of their users according to their needs without harming the nature balanced cycles, by being a part of one or more of these cycles [17,18].

Environmental assessment methods of buildings

Following the principles of Green Architecture, assessment methods have been developed to ensure that buildings meet environmental standards. Using these methods, many assessment certificates are issued for buildings, confirming the environmental commitment of designers and putting them into competition to meet established standards. Assessment methods reduce the negative impacts of buildings on the environment, create a system for comparing buildings to one another, and establish a specific scale for classifying buildings in terms of environmental performance. The assessment includes assessing indoor environmental quality, sustainable sites selection and management, water and energy consumption efficiency, materials and resources selection, and consumption efficiency, the potential re-use and recycling, besides other criteria which are used to judge the efficiency of the environmental performance of buildings. The Building Research Establishment Environmental Assessment Method (BREEAM) is considered the first assessment method, which appeared in the United Kingdom in 1990. Several different methods appeared later in different places around the world, such as (LEED) in the United States (1998), which was applied in 2000, and the Comprehensive Assessment System for Building Environmental Efficiency (CASBEE) which appeared in Japan in 2004 [22–24].

Psychological needs in the current assessment methods

Human comfort requirements are assessed in the Environmental Assessment Methods of Buildings using a set of items, but these items are lacking the psychological needs, while focusing on the physical ones. Several cons were found in the assessment methods regarding the previous point. Some were chosen to criticize their assessed psychological needs, which are LEED, BREEAM and CASBEE. LEED and BREEAM are the most famous and widespread methods, and they are forming with CASBEE the main three methods that others depended on to be produced. The cons in these three methods are showing the cons among almost all the methods around the world. Each previous assessment method focused on the human requirements through a certain assessment field, such as “Indoor Environmental Quality (EQ)” in LEED, “Health & Wellbeing” in BREEAM and “Indoor Environment” in CASBEE [2,22–24]. Assessing the human requirements in these fields is usually related to physical comfort; only few assessment items can be considered related to psychological needs,

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which are not in their ideal form too; and these items can be shown as follows:

- Items that are associated by providing natural light, as it is notable that, besides the benefits of energy savings and the useful chemical components of the natural light, people prefer being in a natural environment than being in artificial one. Generally, artificial environment causes boring and depressing, so these items can be considered psychological items. Some of these items are “Day lighting and Views” in LEED, “Day lighting” in BREEAM and “Day lighting and Views” in CASBEE. In the previous methods, the previous items are achieved according to a certain surfaces area’ percentage that is naturally lit. The item “Daylight devices” in CASBEE can be added to the previous items, and it is achieved when using devices such as fiber optics, light shelves, light ducts, etc., to provide natural light [22–24].

- Items that are associated by providing natural ventilation, these items aim to recognize and encourage adequate cross flow of air in naturally ventilated buildings and flexibility in air-conditioned/mechanically ventilated buildings for future conversion to a natural ventilation strategy. The existing items, mainly aim to reduce the occupational exposure to indoor pollutants by ventilating with outdoor air, and reduce the high energy consumption resulted from the used ventilating devices to achieve a proper thermal comfort for users. When taking into consider the human psychological needs besides the other considerations, then using air-conditioning devices should be the last designing choice in the existing condition. Using devices such as fiber optics, light shelves, light ducts, etc., to provide natural light [22–24].

- Items that are associated by providing an adequate view out. These items allow occupants to refocus their eyes from close work and enjoy an external view, thus reducing the risk of eyestrain and breaking the monotony of the indoor environment. They represent a simple and direct way to connect the external environment, but it is notable that the users may quickly get used to the existing openings and the constant views, then will stop feeling stimulated. Some of these items are “Day lighting and Views” in LEED, “View out” in BREEAM and “Perceived Spaciousness & Access to View” in CASBEE. These items are achieved in several ways, in LEED, it is achieved by providing demonstrates that a certain percentage of the occupied areas have a direct line of site to outside. In BREEAM, it is achieved by providing demonstrates that all relevant building areas have an adequate view out, which are within certain distance of a wall with a window or permanent opening. In CASBEE, the points are awarded according to some dimensions such as the ceiling height, and by provided demonstrates that windows are placed to give all workers an adequate awareness of the outside [22–24].

From the previous, the current assessment items in the assessment methods that are associated with the users’ psychological needs are inadequate and insufficient. The main objectives of the first two groups of items are not directed to the psychological needs, even if they were helpful in achieving some of them. Besides, the third group of items cannot reach a comprehensive psychological comfort when achieved. Instead of dealing with the nature constantly and directly, it is preferred to deal with it in an interactive way to realize and feel its features. Reaching a coexistence with nature helps the users continually responding and enjoying, and drives the nature impact on their senses along with the environment changes. It is also notable that the previous assessment items are depending on quantitative requirements to be measured, which do not suit the subjective characteristics of the psychological needs to be continuously achieved.

Ways to achieve a coexistence with nature through the building surfaces

The building envelope may be divided into walls, roofs, doors and windows, and can also be divided into a number of grouped filters according to their relationship with the external environment. The building filters deal with the external environment in five ways ranging from a complete connection to a complete separation. The five building filter types may be grouped in different ways to create the final building form according to the different conditions and circumstances. The building filters can be divided into barriers, informers, connectors, exposers and switches. The barriers block the nature in the outside as much as possible, informers allow the identification of nature through the building without allowing its passage, connectors allow people and nature to move in and out of the building, and exposers use invisible borders to protect the users while they are dealing with the site and its different functions, while switches are the filter type that can be changed from a previous filter type to another [14]. The development of materials and technology helped the presence of these different filters with their different characteristics. The building filters can be redefined according to the level of connection between the internal and external environments. The level of connection gives the users different feelings, they can sense their surroundings in different ways according to that level, and they can feel their nature in a direct or indirect way, which can both help interaction with nature. In the following, each filter type is suggested to achieve the human coexistence with nature by different ways [8,9].

Using barriers to achieve coexistence with nature

Barriers are the building surfaces that are usually used to separate the internal spaces from the external environment visually and physically, but it should be noted that these barriers with some added concepts can help people interact with their surroundings, such as using integrated audio devices [17].
Some audio devices were developed to be combined with the ceilings and walls to appear as they are producing sounds. These devices may be used to transfer different information to the different internal spaces, and they are connected to a central control, so they can be used for the information, warnings and music. The distinctive feature of these devices that they can transfer the external nature variable sounds to the users directly, for example, the sound of wind or rain can be transferred to the internal spaces. They can also transform the direct sound of the nature elements into musical pieces. These devices can be controlled and stopped in some or all spaces as desired [22]. An example of the audio wall devices is shown in Fig. 1.

Nature sounds can also be transferred into the internal spaces through the building barriers by using some architectural elements, such as water and air channels that may be integrated with the ceilings, walls or roofs as shown in Fig. 2, and these channels help the nature to enter its sound effects directly or indirectly. The water channels may allow the flow of rain in the rainy times through their certain paths, which may end in containers to be used. The rain flow can be controlled to create several musical pieces, if the flow of water was through stone channels, as shown in Fig. 3, and different sound effects will appear with the natural flow changes [10]. Barriers can reflect the outside nature by using digital applications and screens, there are different digital screen sizes that can be integrated with the building components, and after the integration they can be the windows that transfer the external environment visually into the internal spaces. Digital screens can be controlled to simulate the outside nature or give different effects according to its changes, and they can also show prerecorded views from the surroundings, or focus on some natural details in the surrounding environment such as the effect of the sunlight on a near river surface during the day hours as shown in Fig. 4 [13,16].

Using informers to achieve coexistence with nature

Glass windows are the most famous example of informers, they inform the users by their external environment visually and directly, but there are other ways to inform the users using indirect ways, by helping them predicting what is happening in the outside according to inside changes. Instead of looking directly to the sunset, people can enjoy its effect on some internal surfaces due to the changes upon, as users can sensually feel the differences of these surfaces color and pattern in parallel to the phenomenal changes to be informed by it.Feeling the external changes in the surrounding nature in an indirect ways is considered more enjoyable and successful than the direct ways. Some walls can be oriented to be lit every day with the sunset, and others can be oriented to be lit by the sunrise and the users’ arrival. People can feel the existence of clouds in the sky by the light changes on some internal surfaces [13–15]. There are types of glass windows that can give different internal effects, according to the external natural changes, one of these types is a double glazing window that of transparent and partially opaque panels, which helps giving different internal light effects besides the difference in its appearance according to the outside light status, as shown in Fig. 5. Some openings may be oriented to certain angles to give different

Fig. 1 An example of the integrated audio devices to the building walls to transfer some external and internal sounds [19].

Fig. 2 Water channels used on the roof to transfer the rain sound to the internal spaces.

Fig. 3 Using stones to diversify the sound of water flow.
light effects on certain walls, as shown in Fig. 6, the resulted wall colors effects can be graded from gray to yellow then red at sunset [14].

There are several concepts to transfer the external environment variables to the internal spaces indirectly, such as using planes of small linked vials, as shown in Fig. 7. They reflect a certain light portion to allow privacy, excitement, and identification of the external views in diverse ways according to the angle of watching, and these surfaces give sensually depth to the space, and when getting closer to them it becomes easier to focus through. The linked vials can be formed easily using polyester molds and Fiberglass for reinforcement. Such a surface can be used as a building façade overlooking a water view to achieve privacy and enjoy the infinite resulted images at the same time [8,9]. Another type of informers is windows that use a reemerged glass with different angles to change its transparency according to the reflection angles that depend on the viewer position. More other concepts may be generated by using the building form besides its envelope materials to inform users by their external environment. For example, a building of a double metal structure and integrated triangle shapes that cover a red polypropylene envelope of a spaceship form had created a unique informer, as with the sunrise and during its movement in the sky, different enjoyable reflections appear in the internal space, as shown in Fig. 8, and users can predict from these reflections the sun position and the time all the day [14,20].

A series of glass openings can be oriented in a wall to control the light effects in the internal spaces during the day. Furniture can be used also to produce different light effects. Red plush sofas or chairs, for example, may give red flame through the buildings when the light is reflected on its surface during a certain time periods of the day, or certain sun status [14]. Different types of transparent and non-transparent polymers help creating various effects in the internal spaces according to the external environment conditions; each time the light is reflected on their surfaces with different angles, they can create diverse of internal light and shadow effects; and the spaces are redefined continually according to the external conditions [16].
Using connectors to achieve coexistence with nature

The main concept of the connectors is allowing people and nature elements’ movement from the external site to the internal spaces freely, which means the ability of natural air, water, sound, smell and other elements to cross them without borders. The connectors may be partially closed using semi borders like trees, waterfalls and contours. Generally, people prefer to sit on the confrontation edge of such surfaces and do not cross them to the spaces they enclose, and their eyes can see and predict these surfaces using the end edges of the other ceilings and walls besides the ground edges especially if it is raised. So, despite there are some invisible borders, the space can be defined and determined. In some buildings, people can choose their connective preferences with the nature by moving from one space to another according to their desired connective degree with the external environment, and they can cross the connectors to experience different feelings each time. Similar to the seasonal movement that depends on stopping the use of certain spaces during a certain season and moving to others, there is a movement from some spaces to others that can occur every hour or day depending on the desired experience too. These movements need small spaces rather than universal ones to be achieved, as small spaces are easier to be environmentally controlled \[14,20\]. The connectors in cold countries are often used in the south orientation to help people getting warm in a cold day, as shown in Fig. 9. Savoye’s Villa of Le Corbusier in Paris shown in Fig. 10 is one of the most famous buildings with diverse connector surfaces, where they link the internal and external spaces by different ways depending on the contact position. Some rooms have upper openings, others have vertical slots, some have an entire abroad connected wall, some have no connectors at all, and some without a roof. The villa helps people to move through its internal spaces according to their need of communicating the nature and changing their surroundings \[14\].

Instead of the people movement to connect their nature, connectors can be designed to help the nature movement to the indoor spaces to be connected with. If the building is in a very cold region, the building roof is usually a thick cover that prevents the transfer of rain sound into the internal spaces. When noting the people joy of hearing the sound of rain fall on the roofs of their buildings, then people in cold regions may be prevented from such a joy. So, using connectors can solve this problem, these connectors can be tunnels to move the rain and snow into the internal spaces through a glass room to enjoy viewing them besides their falling sound. People can stand near the falling rain without getting wet, or they can touch the water after being heated when desired. Besides, the collected water may be used in several internal uses. So, a vertical space of reinforced double glass may be used in the heart of a double height living space to collect the snow during the time of fallen, as shown in Fig. 11, where snow enters that space to help the users enjoy their falling without feeling cold due to the isolated glass. The users can sit outside the room in different levels to watch the snow falling. In spring, when the snow melts people can touch the water, in summer, that vertical space could contain some of the snow remained from winter \[14\].

Another concept to enter the rain falling sensual effects into the internal spaces is designing a swimming pool on the roof and allowing the water to enter the spaces beneath, as shown in Fig. 12. When it rains, the water falls into an internal pool from holes in the upper pool when the pool exceeds a certain limit of water. The holes can be controlled, and the collected water can be used in the cooling system of the building \[13,14\]. Another concept to benefit the connectors to influence feelings can be related to the moving air. For example, some elements that are freely moving can be used in their path, such as, using wind resonators, as shown in Fig. 13, to create different and enjoyable sounds \[15\].

Fig. 9  People seeking warm in cold days by sitting on the edge of building connector \[14\].

Fig. 10  Villa Savoye, the most famous building of different building connector types \[14\].

Fig. 11  Using vertical space of isolated glass to enjoy the snow effects during the seasons \[14\].
Using exposer to achieve coexistence with nature

Exposers are not physical borders, they can be detected from the shadow ends of some architectural elements, and they allow people to test and feel their environment directly, helping them to stay abroad within their surroundings. People may move within the shade while it is moving in the warm times, or move outside the shade in the cold times, and they also may move in and out of the shade during the day depending on the amount of warmness and light they want. With the sun moving, the exposed area changes, and the people positions change in accordance. Exposers appear in public or uncovered spaces, and in cloudy days the exposers disappear and people may not exist at all because of the loss of the shade boundaries. Despite the exposers are not constructed boundaries, they are considered architectural ones, as people rely on architectural elements to achieve their desired protection when they are abroad. Statues are considered an example of the architectural elements that are used to create exposers, as shown in Fig. 14. In a sunny day these statues act as sundials and the resulted shadow moves and its shape changes over the time [12,15]. Exposers can be used to influence both the sight and touch senses using the manipulation of light and shadow and the contrast between them, as shown in Fig. 15, and the contrast between the light and shadow helps people to focus on their feelings in several ways [15,16].

Using the exposers to give some natural information can be done using several light effects, for example, the shadow at the sunset time may be designed to be extended to infinite in the opposite direction of the sun, and the shadow can be duplicated in several directions with several forms and colors. The architectural elements that are used to create the exposers can have voids to give different sight effects over the time on the nearby floors and walls, which may give them different impressions of volume and weight. Generally, the moving light and shadow on any solid surface give it a fluid effect, and help receiving new images during the hours of the day [13,15].

Using switches to achieve coexistence with nature

The function of the switches is to switch between the previous filter types in the buildings. They can be controlled to be transformed from one of the former filter types to another type or the same type but with different properties. Switching between these filters depends on the people need to connect and experience their surroundings, they can, for example, open doors and windows when they need to connect more with their surround-
ings, and close them when they want to hide them. The level of connecting with the nature can be in accordance with specific ratios that depends on the people preferences and needs. So, architects may design the switches to be ranging between being totally closed to totally opened, to allow different connection conditions with the nature according to the different needs. Users can allow entering or preventing the nature vocabularies and their effect on the user’s senses at different times [14].

Moving louvers can be considered switches in a number of applications, their movement in front of the openings leads to different connection levels, there are a variety in the louvers movement types depending on their three-dimensional form, their technological means, and their construction [9,10]. Fig. 16 shows some of the louver movement examples.

Moveable partitions can be switches, they could control the level of connection with nature by controlling the position and volume of the spaces they move through, these spaces can be extended from the building, thus, the partitions may be moved in different dimensions and change the volume of the spaces they are extended from. In line with the previous concept, some spaces can be a part of the internal spaces or a part of the external environment when needed, two layers of partitions can be used to do so, inner partitions and outer ones. Moving the inner and outer partitions in different ways; gives different connection levels between the internal spaces and the external environment, as shown in Fig. 17, these partitions can have a number of features and additional concepts that help several connection levels [12–14].

The entire walls and roofs of the buildings through their movement in the three dimensions can help change the connection level with the nature too. Walls and roofs can be switched into openings, as they can appear or disappear using different movement types. The walls and roofs position in the three dimensions can be changed by several processes, such as sliding, folding and rotation, Fig. 18 shows only two of the infinite movement types. Building facades can be designed of several layers of the same or different characteristics that can be moved gradually as needed to achieve different connection levels with the external environment, these facades can be a number of different partitions of the same material but with different solid and void ratios that may create different resulting facade forms over the time by their movement besides the different configurations of shadow and light, as shown in Fig. 19. These partitions can also be of different materials to achieve several levels of connection with the nature when switching between them to get different sensory effects, as shown in Fig. 20. In addition [8,9,20].

Other switches types are those responding automatically to certain natural features. For example, smart materials can change some of their properties according to some natural effects, these properties can change the connection level with nature if used, and they also help the users to recognize some of the external natural features according to the occurred changes. Examples of these materials are those that can change their phase (gas, solid and liquid) from one to another and vice versa depending on some natural changes, and the chromic materials that can change their color versus certain natural effects [12,13,17].

The cloud gel can be used between two glasses or transparent panels to change their transparency degree and permeability of light according to the solar radiation received, as shown in Fig. 21, and the resulted glasses or panels are called Thermochromic. When using this material in a building surface, it becomes transparent when the solar radiation on it decreases (in cloudy times) and vice versa. There is a type of liquid crystals that can change the permeability of light according to the exposing temperature, they use colored polymer particles that can be distributed randomly or in parallel to the transparent surface to change it into opaque, and with the increase of temperature, these particles become perpendicular to the surface that becomes transparent gradually. Integrating the poly vinil chloride materials with the glass can change its colorimetric properties according to the sun radiation too, and the polyethylene carbonate and some other polymers can change a number of the surface properties according to the external environment changes daily and seasonally [13,17,18]. Another switch type is the Electroactive Dynamic Daylighting Systems (EDDS), which are multi-layered pixilated electroactive glazing systems that are capable of responding to fluctuating environmental conditions for daylighting and solar control, while providing individual control for visual comfort and information display, and they can diverse the occupant preferences for visual effects and interaction [3], as shown in Fig. 22.

**Proposed items to assess the building role of achieving coexistence with nature**

It is proposed to add some assessing items to the Environmental Assessment Methods of Buildings, such as LEED, BREEAM and others, to achieve a higher level of assessment quality, by improving the human psychological needs assessment besides the physical ones. Noting that reaching continues and enjoyable interaction between human and their nature through the buildings can be achieved by several concepts,

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**Fig. 16** Different movement types of louvers that help achieving different connection levels with the external environment in different ways.
which may form a users’ coexistence with nature. Some of these concepts were introduced previously when expressing the different building filter types, and several other concepts can be added. Thus, number of proper and comprehensive assessment items shall appear in the assessment methods to encourage the psychological needs achievement, and they should be able to cover the different infinite concepts that may appear to achieve a human coexistence with nature through the buildings.

The proposed items can be assessed using quantitative or descriptive ways. The quantitative ways could appear in the form of achieving a certain percentage of the total building envelope that can switch among the different previous filter types according to the users preferences, noting that, these percentages may vary from one method to another according to the natural characteristics and technological level of each country. Generally, measuring the human requirements are more realistic if assessed using descriptive ways due their subjective characteristics [21,25]. So, it is preferred to be assessed using questionnaires for example, to get a more accurate and creditable results. Noting that, questionnaires are easier to be determined for all psychological items than determining different quantitative building requirements for each item according to the method’s country characteristics [21]. If questionnaires are used, a percentage of the satisfied users are determined instead of the building envelope percentage to achieve the desired requirements. Some of the proposed psychological items can be shown as follows:

- Items associated by achieving continues connection between the building users and their external nature, by using the same or different connection levels and concepts over the time, which can be achieved by a number of ways, such as:

Fig. 17  Using inner and outer partitions to change the connection level with nature for some spaces [14].

Fig. 18  Some different walls and roofs movement types that could be used to change their position in the three dimensions.

Fig. 19  Using different partitions of different solid and void ratios to create different light effects when connecting the nature.

Fig. 20  Using partitions of different materials for the same façade to change its connection level with the nature.

Fig. 21  Using smart materials that give the building surfaces different transparency levels, according to the external environment effects.
Coexistence with nature in the environmental assessment

Fig. 22 Example of participant EDDS pattern design and interaction based on position-tracking [3].

- Connecting the users with their external nature over the time using switches, by identifying the building components according to their filtering action.
- Allowing the building users to continuously identify the time and orientation in the different internal building spaces.
- Items associated by achieving continues excitement and stimulation for the building users, which can be achieved by a number of ways such as:
  - Using changeable building components, materials and elements that can be changed according to some changing natural characteristics and events.
  - Using manipulation of natural light effects to create a pleasant internal visual environment to avoid boredom.
  - Using manipulation of the openings materials and their surface properties to influence the senses.
- Items associated by achieving continues interactive between the building users and their external nature, which can be achieved by a number of ways such as:
  - Allowing the building users to control the different natural effects on their senses in the internal spaces.
  - Using intelligent systems, such as interactive displays and compacted digital surfaces, etc., to allow information exchange between the inside on the outside of the buildings.
- Items associated by achieving the building integration with the surrounding environment, which can be achieved by a number of ways such as:
  - Using the building envelope as a part of the interactive balanced natural environment not only as a part of the building.
  - Using some natural creatures and elements to affect the building envelope form, such as the rain, planets and birds.

Conclusion, results and recommendations

Building surfaces can be redefined as filters of different characteristics and connection levels according to their relation to the nature, and these filters can be divided into barriers, informers, connectors, exposers and switches. Each building filter can link the building users with their nature by different concepts to influence their senses in a direct or indirect way. Switches are the most flexible filter type due to its ability of being switched from one of the previous filter types to another. They help to achieve the different advantages of the different filter types they can be changed into in the different time periods according to the different users’ needs and preferences.

Green Architecture is seeking buildings that are similar as much as possible to a useful living creature within the balanced cycles of the nature, which are not only solid masses that control the give and take process within a sustainable limit, so they feature emotional sides besides the physical requirements. In the research, the psychological human needs were condensed within achieving the users’ coexistence with the nature. To achieve coexistence with nature, it is important to change the traditional look to the buildings as a number of barriers to separate the users from the external environment to achieve safety, privacy and physical comfort all the time, and look to them as a part of the surrounding nature that can help the users connecting to the external environment and feel its variation in different ways over the time and connection levels as needed. In that regard, the sunlight, the air, the natural water, even the external creatures and all other natural components are not any more things to be separated from all the time, and they could be used within the buildings according to the chosen connection levels and the used connection concept to help users feel stimulated, excited and belonged to their nature according to their preferences and the external circumstances.

The Environmental Assessment Methods of Buildings were set to ensure that buildings meet environmental standards that are set according to the Green Architecture principles. The current methods rarely consider the human psychological needs in their assessment items, and the items that may be considered in that direction are not leading to the expected desired continuous satisfaction. Therefore, it is suggested in the research paper to add some new items to the current Environmental Assessment Methods of Buildings to assess the buildings ability of helping the users feeling a coexistence with their nature. The purpose of these items is mainly to guarantee the human ability to control and connect his natural surroundings continuously. These additional items could be added temporarily to the innovation items until the designers get used to it. They are preferred to be assessed using descriptive and subjective processes such as questionnaires.

All the developers of the assessment methods are recommended to add the proposed items and start focusing on assessing the human psychological needs as an important environmental issue. Researchers are recommended to develop the proposed items to help considering them in a more appropriate way within the Environmental Assessment Methods of Buildings. Designers are recommended to find innovative concepts to connect the building users with their external environment in different ways and positive psychological influences.
Conflict of interest

The author declares that there is no conflict of interest.

References


