Biophilic design reframed. The theoretical basis for experimental research

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Abstract

Biophilic Design is a design system based on Kellert and Wilson's Biophilia Hypothesis. Biophilia is literally 'love for life' – a feeling distinguished by the fascination evoked in human beings for Nature provoked by contact with Nature and by the affiliation that human beings establish with Nature. Biophilia is an evolutionary adaptation consisting of a set of innate learning rules that shape a spectrum of emotions, ranging from biophilia to biophobia. Two exaptations have been recognised in Biophilia, which occurred due to two moments of rupture of humankind from Nature: the first occurred in the Neolithic Age, the second with the Industrial Revolution which led to most humans becoming urbanized, disconnecting them from Nature. Designers following the principles of Biophilic Design seek to reconnect humans to Nature using our knowledge of biophilia as a guide for the design of artificial environments. Today, Biophilic Design is called to move away from empiricism, and instead implement the experimental tests of the Biophilia Hypothesis.

La Progettazione Biofila è un sistema di progettazione basato sull'Ipotesi della Biofilia di Kellert e Wilson. La biofilia è letteralmente 'amore per la vita', un sentimento caratterizzato dalla fascinazione che la Natura esercita sugli esseri umani e dall'affiliazione che gli esseri umani stabiliscono con la Natura. La biofilia è un adattamento evoluzionistico che consiste di un insieme di regole di apprendimento innate che danno forma ad uno spettro di emozioni, che vanno dalla biofilia alla biofobia. La biofilia ha subito due ex-adattamenti, in seguito a due momenti di rottura con la Natura: dapprima nel Neolitico e poi con la Rivoluzione industriale, che ha urbanizzato la maggior parte degli esseri umani, disconnettendoli dalla Natura. I progettisti cercano di riconnettere gli esseri umani con la Natura utilizzando la biofilia come guida per la progettazione di ambienti artificiali. La Progettazione Biofila è chiamata oggi a uscire dall'empirismo, implementando le verifiche sperimentali della Ipotesi della Biofilia.

Keywords

Biophilia Hypothesis, Biophilic Design, Evolutionary adaptation, Connectedness to Nature, Neolithic, Industrial Revolution.
Ipotesi della Biofilia, Progettazione Biofila, Adattamento evoluzionistico, Connessione con la Natura, Neolitico, Rivoluzione industriale.

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We live in an era of strong disconnection from Nature[1]. We know that disconnection from Nature, the 'extinction of experience' of Nature (Miller, 2005), causes both physical and psychological damage (Frumkin, 2001). Our disconnection from Nature has often been a decisive element of behaviours which have even resulted in changes to the nature of the Earth, so much so that scientists have defined the current geological era as the Anthropocene (Creutzen, 2006). Indeed, when a person becomes aware of the damage they inflict upon Nature, they may feel a particular sense of guilt, a specific sentiment now known as 'solastalgia' (Albrecht, 2005).

As humans, we instinctively feel the need to reconnect with Nature: we are called to her. This appears to occur in many human activities, such as in the designing of the buildings in which we spend much of our time: our homes, schools, offices and hospitals. Even the so-called *non lieux*, such as airport waiting rooms or large shopping centres, have become the subject of interest in the architectural field of Biophilic Design, namely "the deliberate attempt to translate an understanding of the inherent human affinity to affiliate with natural systems and processes – known as biophilia – into the design of the built environment" (Kellert, 2008, p. 3).

I have been involved in the study of Biophilic Design for fifteen years now and I have witnessed the interest in this topic grow enormously (Barbiero, 2017). However, this growth in interest has not been accompanied by an appropriate growth in the awareness that Biophilic Design requires a rigorous scientific approach based on the Biophilia Hypothesis and its experimental verifications. Even today, Biophilic Design mainly applies an empirical approach. Many designers, knowing that contact with Nature is good for us have simply added a little vegetation to their designs. The problem with empiricism is that it only works whilst everything is going well. But when a problem emerges, we don't know what to do and empiricism can't help us. We need a more scientific approach. The scientific basis of Biophilic Design lies in biophilia, and biophilia has been experimentally verified through controlled experiments (Barbiero, Berto, 2024). The Biophilia Hypothesis is now accepted as robust and provides the conceptual framework within which Biophilic Design can be rigorously tested (Barbiero, 2021).

The biophilia hypothesis

Biophilia is 'love for life'. The term 'biophilia' is the combination of two ancient Greek words, 'life' (βίος) and 'love' (φιλία), and it was coined by the German psychologist Erich Fromm (1900-1980) to describe the psychological orientation of being attracted to everything that is alive and vital (Fromm, 1964).

Fromm addressed biophilia from an ontogenetic perspective, aimed at identifying the conditions necessary for a biophilic personality to develop. Subsequently, the American biologist Edward O. Wilson (1929-2021) independently introduced the concept of biophilia to describe the traits of evolutionary adaptation that allow us to develop a psychic bond with the living world and with Nature (Wilson, 1984). Wilson's approach was phylogenetic and aimed to understand the conditions required for biophilia to remain an effective adaptation over time. By consequence, biophilia lies on the boundary where biology and psychology merge. In this paper I will describe the biophilia hypothesis using the tools of evolutionary biology and environmental psychology to identify its fundamental constructs, through which we can then define the potentials and limits of Biophilic Design.

The constructs of biophilia. Fascination and affiliation

The *Biophilia Hypothesis* was formally presented in 1993 by Stephen R. Kellert and E. O. Wilson in a book (Kellert, Wilson, 1993) which collects contributions by evolutionary biologists (Lynn Margulis, Michael E. Soulé), environmental psychologists (Roger Ulrich), anthropologists (Jared Diamond, Richard Nelson), ecologists (Gordon Orians, Gary Paul Nabhan, Madhav Gadgil), deep ecologists (Paul Shepard, David Orr) and philosophers (Holmes Rolston III) to describe biophilia from different points of view.

Wilson subsequently refined the hypothesis further, defining biophilia as "our innate tendency to focus upon life and life-like forms and, in some instances, to affiliate with them emotionally" (Wilson, 2002, p. 134). This definition of biophilia is of great importance, because it identifies two fundamental constructs of biophilia: the fascination that Nature evokes in human beings and the feeling of affiliation that human beings feel for Nature in certain circumstances.

'Fascination' is the form of attraction capable of activating involuntary attention – attention that requires no effort (Kaplan, 1995). People respond to natural environments with involuntary attention, which in turn permits directed attention to rest and recover from mental fatigue in both adults (Berto, 2005) and children (Barbiero et al., 2014).

'Affiliation' is an emotional bond that is established with particular forms of life and that occurs in certain circumstances. From an evolutionary point of view, the feeling of affiliation lies in our ability to empathize with other creatures and respond to their needs as if they were our own (Goodenough, 1998). The ability to be empathetic can be a good predictor of the ability to affiliate with Nature (Di Fabio, Kenny, 2018) since empathy is an emotional state triggered by the emotional situation of another person (Hoffman, 2008). Experiencing emotional involvement with Nature is the first step to developing a feeling of affiliation with Nature (Barbiero, Marconato, 2016).

Empathy normally develops between two human beings; however, the ability to experience empathy is not limited to humans (Angantyr et al., 2011). Forms of differentiated emotional involvement and asymmetric empathy are widespread in mammals (Preston, de Waal, 2002). Nature, especially domesticated Nature, offers ample opportunities for empathic contact (Hand et al., 2017) and can help reduce the stress response (Sapolsky, 2004, pp. 234-248; Ulrich, 1984).

Biophilia and biophobia

According to Wilson, "biophilia is not a single instinct but a complex of learning rules that can be teased apart and analysed individually. The feelings moulded by the learning rules fall along several emotional spectra: from attraction to aversion, from awe to indifference, from peacefulness to fear-driven anxiety" (Wilson, 1993, p. 31). From this statement, we can infer the following: (1) biophobia – i.e., fear and strong avoidance responses to certain natural stimuli that presumably constituted risks during evolution (Ulrich, 1993, p. 76) – is intrinsic and complementary to

biophilia; (2) biophilia is innate but it is not instinctive (Lee, 2012). It is innate insofar as it constitutes a manifestation of a phenotype that passed the scrutiny of natural selection and can be studied from a phylogenetic perspective. It is not instinctive because it does not give rise to behaviour that is rigid and fixed in a deterministic manner. Over the course of evolution, biophilia – through a process of coevolution of culture and genes (Wilson, 1993) – has become part of the human genotype (Kellert, 2009), conferring an advantage in terms of real fitness to those individuals capable of affiliating emotionally and creatively with the environment (Kellert, 1997, pp. 1-9).

Biophilia is ubiquitous in human cultures

Many evidences indicate biophilia to be a hereditary trait. First, biophilia is ubiquitous in human cultures, it is an 'absolute universal'; no cultures are known to exist devoid of biophilic traits (Barbiero, Berto, 2021). When a psychic quality is an absolute universal, we can hypothesize it to be a psychobiological trait, forged over the course of evolution (Brown, 2004). Secondly, biophilia possesses the four characteristics considered to be typical of a temperament trait (Strelau, 1998, p. 165): (1) it is present from early childhood; (2) it has a counterpart in animals, for example, it manifests in behaviours associated with the raising of offspring and the search for shelter and resources; (3) it is determined by innate biological mechanisms; (4) it is subject to changes caused by the individual's maturation and genotype-environment interactions specific to each person. Therefore, biophilia could be a relatively stable trait of the basic personality which is expressed in an individual's reactions to Nature and their resulting behaviour.

Biophilia is innate but not instinctive

Whilst biophilia is innate, it is not instinctive. Instinct guides behaviour in a precise manner, but a behaviour that is too precise is stereotypic, i.e., incapable of benefiting from learning and experience (Barbiero, Marconato, 2016). We are genetically predisposed to learn what Nature can teach us, to acquire knowledge from our experiences: the code of behaviour is genetic, but its expression depends on our specific experiences of Nature. Biophilia consists of "weak learning rules" (Wilson, 1993, p. 32) that leave ample freedom to the individual. Those which have been selected and inherited are not sequences of responses or particular behaviours but rather a greater susceptibility towards certain environmental stresses and towards the possibility of establishing specific links between individual reactions and situational contingencies (Caprara, Gennaro, 1994, p. 491). Human behaviour is not influenced by instinct as animal behaviour is. Indeed, it was clear to Fromm that the function of character is to replace the instinctive tools that human beings lack (Fromm, 1973, p. 255). Education is fundamental for character formation (Williams, 2000), and it may or may not favour the formation of a biophilic personality. Biophilic education cannot occur in the absence of contact with Nature (Kahn, 2002) because "when human beings remove themselves from the natural environment, the biophilic learning rules are not replaced by modern versions equally well adapted to artifacts" (Wilson, 1993, pp. 31-32).

Biophilia is an evolutionary adaptation

The biological evolution of our species occurred in the 'wilderness', the wild Nature of the Late Pleistocene. For approximately 95% of our evolutionary history, humans survived adopting hunter-gatherers' lifestyles and lived according to Palaeolithic culture. Their conditions required them to perfect a set of adaptive responses to different wild environments that permitted them to recognize the qualities of an environment in terms of the shelters and resources it offered (Buss, 2016, pp. 70-84). Safe and resource-rich environments are one of the preconditions of biophilia (Fromm, 1964, p. 68); their presence reduces the stress response and promotes the restoration of co-

gnitive processes (Berto, 2014). Some of our environmental preferences (Balling, Falk, 1982; Robinson, Breed, 2020) could, therefore, be rooted in the adaptations of our ancestors which proved to be effective in their struggle for survival (Falk, Balling, 2010). Furthermore, the capacity to recover from mental fatigue more quickly in safe and resource-rich environments may have conferred an additional evolutionary advantage (Kaplan, Kaplan, 1989, p. 181).

Our relationship with Nature changed during the Neolithic Age, which covers the remaining 5% of humanity's evolutionary history (Larson et al., 2014; Stephens et al., 2019). Following the invention of agriculture (Purugganan, Fuller, 2009) and livestock farming (Larson, Fuller, 2014), around 14,000 years ago (Arranz-Otaegui et al., 2018), humans began to distinguish domestic (good) Nature from wild (bad) Nature. This may have pushed the biophilia trait to enter a new cycle of adaptation/exaptation (Gould, Vrba, 1982) which allowed for the development of novel uses of former adaptations in response to the demands of the new Neolithic lifestyle.

With the Industrial Revolution, which started in the second half of the 18th century, an irrelevant period from an evolutionary point of view – corresponding to less than 0.1% of our history – humans began to create urban environments, characterized by an increase in population density and a decrease in green spaces (Szreter, Mooney, 1998). During this period, the size of urban agglomerations grew, and they presently account for the living environment of more than half of the world's population[2]. Visible Nature has almost, although not completely, disappeared from urban environments (Beatley, 2011, pp. 17-43), thus the abundance of natural stimuli favouring the development of biophilia has similarly been greatly reduced (Barbiero, 2021).

The Neolithic Age and the Industrial Revolution generated two moments of rupture with Nature, first with wild Nature (the wilderness) and then with domesticated Nature (farmlands). Although these two moments of rupture have strongly influenced the processes of enculturation, the predisposition to learn from Nature has remained intact (Wilson, 1993). In fact, while the nature of the Nature from which we can learn has changed, there are many signs to suggest that the imprint of the wilderness remains deeply ingrained within the human psyche (Barbiero et al., 2023).

From biophilia to Biophilic Design

Stephen R. Kellert (1943-2016), an ecologist at Yale University and co-author of *The Biophilia Hypothesis* (Kellert, Wilson, 1993), is the father of Biophilic Design. In 2006, Kellert organized the Rhode Island Conference where the term 'Biophilic Design' was used

for the first time to define a design system inspired by biophilia. In the book *Biophilic Design* (Kellert et al., 2008), Kellert gathers the experiences of biologists, psychologists, and architects together, all of whom are united by their common interest in artificial environments that respect human biophilia. The first chapter of the book *Dimensions, Elements, and Attributes of Biophilic Design* (Kellert, 2008) continues today to be an important reference point for studies in Biophilic Design.

The goal of Biophilic Design is only apparently simple. Kellert recognized two factors which limit the potential to develop an effective Biophilic Design: "the limitations of our understanding of the biology of the human inclination to attach value to n/Nature, and the limitations of our ability to transform this understanding into specific approaches for designing the built environment" (Kellert, 2008, p.3). In this way, Kellert was also able to recognize two dimensions of biophilic design. The first is a 'naturalistic' dimension, inspired by the biophilia that established itself during the Palaeolithic. The second is a 'vernacular' dimension, developed during the Neolithic Age. Kellert related these two dimensions to 72 Biophilic Design attributes (Kellert, 2008), which were then implemented in various systems of building certification (Sturgeon, 2017) and provided a basis for the Biophilic Quality Index (Berto & Barbiero, 2017). Tragically, Kellert's life ended prematurely in 2016, but thanks to his wife, Cilla, his book *Nature by Design* (Kellert, 2018) was completed and published two years later. Here, Kellert tried to systematize Biophilic Design according to three categories: Direct Experience of Nature; Indirect Experience of Nature; and Experience of Space and Place. Kellert proposed a series of suggestions aimed at helping designers incorporate humankind's affinity with Nature into the built environment. These suggestions offer a series of options for using Biophilic Design in an effective manner, as long as it is done in a way that respects the specificity of each project, rather than as a checklist to be applied indiscriminately (Kellert, 2018, pp. viii-ix).

A pragmatic approach to Biophilic Design was proposed by the consultancy firm Terrapin Bright Green (TBG), founded by Bill Browning and Cook&Fox Architects. The basis of their proposal was the fruit of a systematic review of the literature in environmental psychology, namely studies investigating the effects of the built environment on human beings. Their aim was to identify design patterns that had both a scientific basis and were feasible for architects to apply in Biophilic Design (Browning et al., 2014).

Bettina Bolten and I compared the characteristics of Biophilic Design described in the most scientifically relevant publications in order to identify the issues which authors unanimously reported to be funda-

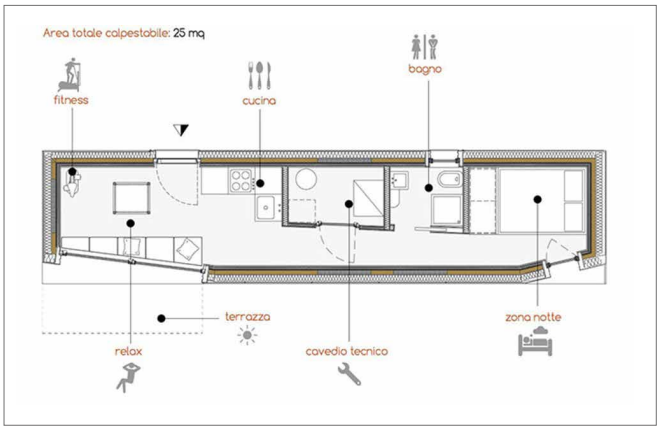


Fig. 1 - Biosphera 2.0 plan. © AktivHaus.
Fig. 2 - Indoor of Biosphera 3.0 "Equilibrium". © AktivHaus.
Fig. 3 - Biosphera 4.0 "Genesis" tested at San Servolo Isle, Venice, Italy. © Aktivhaus.

mental for Biophilic Design (Bolten, Barbiero, 2020). We noted that four of these 'issues' (light, air, views and protection) are also considered essential in Evolutionary Psychology for the search for shelter, whereas three 'issues' (greenery, materials and curiosity) are considered essential for the search for resources. From this, we can note – unsurprisingly – that the characteristics of Biophilic Design considered universal are, in fact, in keeping with the evolution of *Homo sapiens* in the search for a habitat with safe refuges and reliable resources.

Experimental tests of Biophilic Design

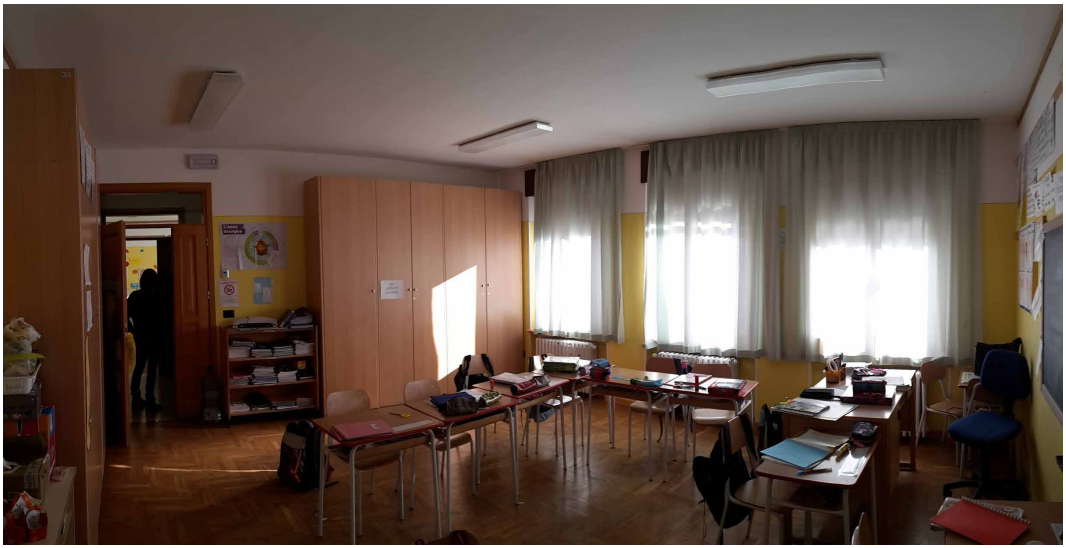
The Laboratory of Affective Ecology (GREEN LEAF) at the University of the Valle d'Aosta, Northwest Italy, has developed two approaches to test Biophilic Design experimentally. One line of basic research has been carried out as part of the *Biosphera Project*. The other line of research regards Biophilic Design in the context of schools, or *Innovative Learning Environments* (ILE) based on Nature.

The Biosphera Project, owned by AktivHaus®, creates experimental energetically autonomous housing units using the most advanced and innovative technologies available today. The prototype is 'Biosphera 2.0' (fig. 1): a 25 m^2 transportable housing module, equipped with all the essential services useful for everyday life and cutting-edge installations, such as photovoltaic solar panels, LED lighting to reduce artificial lighting impact and new generation sensors to optimize energy performance, as well as the scientific instrumentation necessary to study the reactions of the human organism to changes in environmental conditions outside the module. The module is energetically self-sufficient and capable of maintaining an indoor temperature of 21°C in the winter and 25°C in the summer without resorting to external energy sources. Our task at Biosphera was to eliminate environmental stressors in the design phase, a prerequisite for creating a biophilically designed environment (Ulrich et al., 1991). To test the effectiveness of our work, we monitored 29 volunteers (14 males and 15 females; average age 33.7 years) who agreed to spend a few days and nights in Biosphera 2.0. The results showed that the participants both recognized and appreciated the absence of environmental stressors (Berto, Maculan, Barbiero, 2020). In version 3.0, 'Biosphera Equilibrium' (fig. 2), we experimented with some Biophilic Design patterns in different external environmental contexts. Whereas in version

4.0, 'Biosphera Genesis' (fig. 3), our aim was to combine Biophilic Design with Chronobiology.

The experience gained from the Biosphera Project and from other projects (Berto et al., 2015; Berto et al., 2022; Stocco et al., 2023) was subsequently applied in a project in which we refurbished a primary school in Gressoney-La-Trinité in the Valle d'Aosta, Italy, and investigated the effects of Biophilic Design on the students' attentional performance and on their affiliation with Nature. We compared a conventional learning environment (fig. 4) with Nature-based ILE environment (fig. 5) built according to the Biophilic Design approach of Terrapin Bright Green (Browning et al., 2014) and the Biophilic Quality Index (Berto, Barbiero, 2017). The experimental observations spanned three academic years: they were carried out in a conventional learning environment in the first year and in a biophilic environment in the following two years. The students were assessed at regular intervals at three different times (in the autumn, winter and spring) of each school year. (in the autumn, winter and spring) in each school year. The results showed that in addition to being preferred and perceived as more regenerative, biophilically designed learning environments were more effective in supporting the attentional performance of students compared with conventional learning environments; moreover, over time, they strengthened the students' feelings of affiliation with Nature (Barbiero et al., 2021). The Gressoney-La-Trinité project was subsequently extended to involve nine schools of the Unité des Communes Valdôtaines Grand-Paradis and the Biophilic School in Jovençan, where Biophilic Design was integrated with the local traditions in a project carried out by Vernacular Design.

The goal of Biophilic Design is to design artificial environments that have a positive effect on the health and well-being of those occupying the spaces. These positive effects must be measurable. Furthermore, to ensure that the biophilic quality of architectural projects continues to improve, it will be necessary to develop guidelines based on the results of purposely developed tests conducted according to scientific criteria. These guidelines could then be converted into a manual to assist designers and ensure the success of their work. Biophilic Design is considered successful when it is able to reconnect humans to Nature (Kellert, 2018, pp. 14-16), a much more ambitious goal than simply bringing Nature into man-made spaces. Biophilic Desigsn strikes chords deep within the hu-



man psyche. These chords being touched are linked to our need to rediscover an affinity with Nature and feel united with it once more (Barbiero, Berto, 2021), which also involves accepting the dangerous side of Nature, which arouses biophobic reactions within us. Reconnecting with Nature does not mean returning to the lifestyle of Palaeolithic hunter-gatherers but knowing and enhancing the aspects of reconnection that allow us to achieve physical and mental balance more quickly and more effectively.

Notes

[1] In this paper, 'Nature' is written with the capital 'N' to indicate the biosphere and the abiotic matrices (soil, air, and water) where it flourishes, and to avoid confusion with 'nature' as the intrinsic quality of a certain creature and/or phenomenon.

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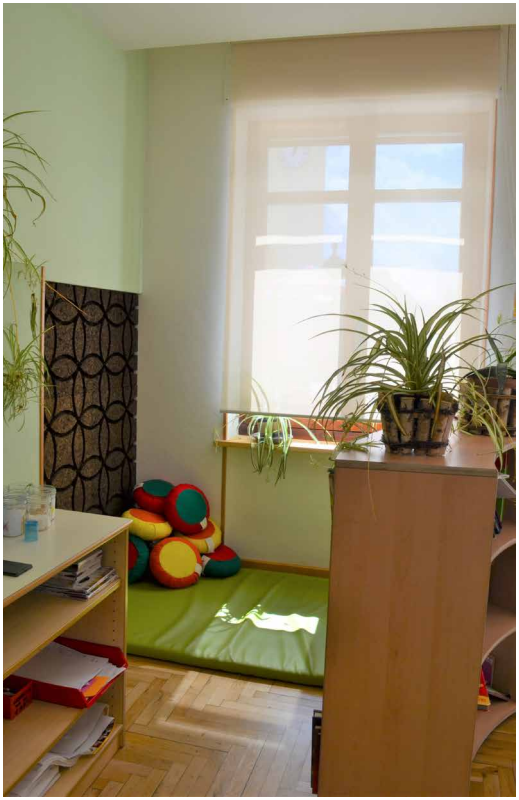

Fig. 4 - The Gressoney-La-Trinité classroom before the building requalification. ©Alice Venturella.

Figg. 5a, 5b - The Gressoney-La-Trinité classroom after the building requalification. Points on dynamic light and sense of protection issues. © Nicola Maculan and Alice Venturella.

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