



CONNECTIVITY

and **CREATIVITY**

in times of **CONFLICT**

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Preface

Connectivity and Creativity in times of Conflict - conference proceedings VI
 Cumulus president's message - Design for Adaptation in Times of Complexity IX

Track 1

Nature positive/design for transformation

Editorial 2
Design methodology
 Scenario-building through a systemic lens: a new perspective on tools and methods to design for sustainability transitions 4
 Intimacy/integrity: a framework for thinking about epistemological styles in design activity 9
 Democratizing design: the development of a 'Design for Do-It-Yourself' framework 15
 The power of imagination: immersive and experiential counterfactuals to engage with sustainability 20
 Applying human-centered system design to the development of a tool for service innovation 25
 Pulse approach: integral design project management to empower transformative processes 30
 Research on design sketch from different disciplines: overview and directions 35
 Researching the invisible: troubling qualitative research design through information architecture 41

Design education

T+ designers: a case for transdisciplinarity in design higher education by way of a South African case study 46
 Materiality, commons, and design education 51
 Representing and shaping regenerative futures: a context-specific approach to art and design education. 58
 Creative strategies for the learning spaces of the future 62
 Implementing SDGs in a product design curriculum, or: the value of tap water 67

Design materialization

Yutaka: how do we prototype the transformative change towards nature positive designs with soil 72
 Material experience: the future of material selection for product design 77
 Discerning modes of design in ecological restoration 82
 From visual to multisensory: how does intangible cultural heritage of traditional costume self-remodel in digital interactive environment? 87
 Designing sustainable furniture: guidelines to promote furniture life cycle design 94

Biophilic approaches in design

Biophilic design for remote studying environments: analysis of case studies involving a collaboration between ergonomics and environmental psychology 98

Bioreceptive interfaces for biophilic urban resilience 103
 Artificial nature: possibilities for mycelial composite material design 109
 Botanical design: exploring the application of parametric plants in furniture 113

Eco-social transitions

Systemic Design Oriented Leadership (SDOL) – a co-created play for eco-social leadership development with the methods of Systems Thinking 118
 Design for transformation: unlock competencies for coping complexity 122
 Change agents: designers interpreting 'the social' and 'social' interpretations of design 127
 The changing role of designers in transition processes 132

Fashion innovations

Fashion design matter: the role of design in guiding a sustainable transformation in Europe 137
 Convincing fashion consumers to go green: a brand communication problem? 142
 Prototype dialogues; re-balancing design thinking through negotiations with fabrics, form and future 148
 Future fashion: new and ancient systems at the intersection of anthropology, ecology and innovation. 152

Urban design & citizen inclusion

Design fiction localised 158
 Transit Oriented Development used to formulate design guidelines for an improved bus network in Malaysia 163
 Exploring sustainable ecosystems in the "15-minute" urban living circle—take Shanghai Urban Space Season 2021 as an example 169
 The Unified Citizen Engagement Approach: a design-oriented framework for involving citizens in the energy transition 174

Design & digitisation

Designing for Viral Infection Awareness through PLAYMUTATION 179
 Gamifying the low impact customer solution design 183
 Connecting to the future; using serious games and scenario development for responsible design 189
 About utopias, apocalypses, respawning and zombies and how understanding images of space and time may inform design for sustainable behaviour 194

Track 2

Digital futures/hybrid reality

Editorial 200
New crafts and craftspeople
 Fashion Craftsmanship 4.0. Learning experience about Industry 4.0 technologies for hybrid digital fashion-tech products, processes, and business model design 202
 Crafting hybrid workflows for the design of augmented textile artefacts 210

Distance: digital immersive technologies and craft engagement	214	Fantastical reality: designing virtual urban space through extended reality	333
Notions of hybrid craft production: conversations and small-scale experiments in digital fabrication	219	The Metapolis – cities between a ripple and a blur	338
Research through design in the cyber-physical era		Towards data activation and engagement within a smart city	345
Digital synesthesia in product design. Building a vocabulary of physical interactions for a sensible quantified self	223	Technology driven design education	
Digital content that offers experience of listening to crystallized music	228	Teaching design of technologies for collaborative interaction - an emerging pedagogical framework	349
The body can not be thought: the 'disabled body' as a catalyst to develop new paradigms for human-computer integration.	232	A mixed-method approach: virtual reality to co-create future higher education workspaces in a post COVID-19 academic environment	357
Metaphysical Instruments: prototypes for hybrid and live music-making	236	An attempt to integrate AI-based techniques into first year design representation course	363
Redefining the role of design(ers)		Digital fashion	
Virtual skin: co-creating 3D materials with synesthetic artificial intelligence	241	The emperor is naked: deconstructed materiality in fashion NFTs	368
Cabinets of curiosities for the postcolony II: tokens: collections I-V	245	Dematerializing fashion- improving design-led sustainable and hybrid retail experiences via digital twins	372
Speculating futures in an age of nostalgia	250	Fashion archive as a meta medium: unfolding design knowledge through media technologies	379
Computational thinking in design and fabrication for augmented and accessible museums.	254	Fashion and the metaverse: from omni-channel to direct-to-avatar	384
Usability and performance of innovations		Track 3	
Usability and UX evaluation of an online interactive virtual learning environment: a case study of Wales' Virtual Hospital	260	Handle with care/inclusivity	
Design perspectives for the future of work in Industry 5.0 environment: the digital and physical space in Augmented Reality uses	266	Editorial	
Assessing the impact of immersive versus desktop virtual reality shopping experiences in the fashion industry metaverse	271	Design for/as communication	
A pilot study with the Shaper Origin to determine the learning curve of augmented fabrication	276	Encouraging humanitarian assistance in conflict zones through animated public service announcements	392
Design for and with extended reality		The design of an engaging focus group discussion toolkit involving school-aged children following urotherapy	397
Introducing the material experience concept in the metaverse and in virtual environments	280	Inclusive Transformation of age-friendly communities based on digital technology support	402
Balancing authenticity and creativity: A VR system design for assisting in ceramic creation.	287	Taking care of the elderly through the tools of the animated communication design: a useful and ethical imperative	408
What is the furniture in the Metaverse for?	292	Pee poo period. Exploring the intersection between shame, bodily fluids, and sustainable design	413
Design for and with digital fabrication		Design for diverse users	
Craft in the age of robots	299	Feminist value sensitive design of self-tracking technology based on female body data	419
Light it up: designing electronic textile with a light as a design material	304	Spatial "mutual altruism" as a relationship of care for homeless people. How design impacts social re-integration	425
Strategy for knowledge transfer in AM as a hybrid process chain towards a transition from prototyping to commercialisation	309	I'll be there for you: exploring a sense of belonging to enhance student engagement	429
Speculative tinkering on circular design materials through 3D printing	317	Inclusive design in the context of performative gender through product form	433
Flaws as features, new perspectives for developing an additive manufacturing design language	322	Landing the internship: the role of gender in finding ID internships	438
The digital on urban scale		Object as the tool of recovery - Examining material culture of young refugees in Hungary for trauma processing	443
Designing smart product-service systems for smart cities with 5G technology: the Polaris case study	328	The food delivery industry and its lack of care in gender equality: the speculative case of 'GiGi'	448
		Winning at more than a game! A storytelling board game concept to raise awareness about refugees' language barriers	455

Care(ful) spaces

Cities for all: co-design interventions on urban features using inclusive technology	461
Separating Covid from non-covid: spatial adaptations in existing hospital buildings	466
Wayfinding is caring	471
Explore vacant public spaces regeneration to facilitate minor's activities and education under inclusive design principles	475
Human-space relationships as narrative processes for inclusivity	480
Urban darkness: human experience of atmosphere and fear	485
Daily social interactions of hawkers as a catalyst to actuating bottom-up spatial justice: experience from Hong Kong	489
The city of care through walkability and proximity. Researching on and with Generation Alpha on urban walkability assessment	494
Hinges, passages and comfort	499
Renewal of urban ecological transportation network based on inclusivity design — Take Sydney's "Livable Green Network" plan as an example	504
How to take care of the Antwerp modernist social housing of Alfons Francken? And how do this housing blocks take care of its changing population?	510
Inclusive innovation: a study of creative furniture design for urban community public space	515

Co-creating care(ful) design

Health, care and prosthetics: co-design methodologies in the case of autofabricantes	519
See the unseen: a co-creation design process for children with incarcerated parents	524
The power of photovoice: AI support provides voicing opportunities for children in sex education	529
Co-design for the common good: a holistic approach to workspace projects	533
Co-designing neighbourhood identities. How to share memories and experiences towards a common sense of belonging	538

Design(ers) & learning

Universal design for learning as an inclusive teaching methodology for an African art and culture course in Ghana	544
Material-led thinking as a practice of care: a strategy from art and design education	550
Artful care for self and others in daily design practice	555
Material metaphors: method for physicalising relations and experiences	560

Design ethos

A South African approach towards a caring design practice	565
Weighing the tensions of nostalgia, necessity, and care in contemplating the future of the Nigerian design-scape	570
Food as a form of care: designing social innovative processes and practices	575

Designing with posthuman kinship: from posthuman theory to human-non human collaborative design approaches	580
Beyond empathy: how curiosity leads to greater care	585

Inclusive approaches to intangible cultural heritage

Convention versus contemporaneity: the affordances of design-led mediation towards sustaining an ancestral cycle of linen making in Castelões, Portugal	590
Combining care for planet, people and culture towards circularity	594
Media art creation process using digitized archetype of Korean traditional dance movement	600
Envisioning design strategies for intangible cultural heritage activation	604

Sustaining traditional crafts and techniques

Craft for care, design for life. Heritage contemporary enhancement and communication design tools as a resource for social changes, fostering diversity and inclusion	610
Embroidered heritage: a design-led visual ethnography of traditional Palestinian motifs	615

Adaptation of the built environment

Design for Ukraine's heritage: engaging international students during times of war through design activism	619
The technical compatibility of vertical greening with built heritage	624
New design models for proximity retail and senior inclusion	628
Investigating spatial patterns of green infrastructure at built heritage sites in Antwerp, Belgium	632
From architecture to community: adaptive reuse as social practice	636

Participation and role of communities

Methodology and evaluation of digital assets reconstruction of cultural heritage with visitor participation in museum	642
Community heritage: an immersive approach to disaster resilience	646
Caring for human diversity and built heritage through design: a multiple case study enquiry	651

Poster abstracts

Adding value to the future through design and entrepreneurship: PLACE	657
A video game for emotion regulation of medical students	658
Video game design for ecological impacts	659
Dwell and move, change ensues	660
Transposing timelines	661
Artificial intelligence-aided type design for Chinese script	662
Design and reconstruction of the new interest youth community in china in the post-epidemic era	663
Sound E-scape: an interactive, digital application for music therapy and soundscape generation	664
Development of existing biophilic interior design definition	665

Design-driven approaches to human augmentation. An exploratory study	666	Human augmentation: the role of design in the design of on-body interfaces for cognitive-sensorial wellbeing	718
Designing with people: creating a multi-level interdisciplinary design education environment for more inclusion	667	A conception toward design narratives for innovation	721
Material connotations: meta-structure research of practice based projects with invasive species plant waste	668	Home away from home – The role of design methods in processing trauma of forced migration and loss of place	725
From collecting natural objects to presenting the future anthropocene: exhibition design for the anthropocene theme in museums	669	Decoloniality and healing: confronting inter-generational trauma/ideologies through architectural preservation and education	728
Catacombs: refuge on the border of the virtual and the real	670	The ephemerality of an organic material and its implications: a context specific study with invasive exotic species (Japanese knotweed) waste in Genk, Belgium	731
Hybrid specimens: Phygital artefacts at the intersection of analogue + digital crafts	671	Visual communication bridging intercultural barriers	734
Content management system in mapping movable objects	672	Feeling the future car: designing for driving pleasure in the era of co-driving	737
FlavourGame: interaction design in hybrid games	673	Mediterranean landscapes in emergency: nature and culture	739
Bibliometrics in circular design visual representation	674	Key Performance Indicators for measuring and evaluating users' sensory perceptions and behaviors in learning spaces in higher design education	742
Inclusivity as a hype phenomenon in advertising	675	Textile handcraft making and women creators' psychological well-being: a narrative review	746
Inclusion in recruiting	676	Cross-case analysis on the integration of extended reality (XR) with the design and planning of the built environment	750
Values, design and educational project: contemporary projections	677	Ecosystem services: an interpretive paradigm of urban and territorial heritage. Strategies, guidelines, and vision for sustainable cities	754
Project Hope : the creative revolution mural, a human singularity approach	678	Characteristic analysis of future-oriented design based on cognitive context theory	757
More-than-human ways of thinking through felting wool	679	Digital wellbeing and design	760
"Care strategies to strengthen heritage structures as a community asset during the pandemic: the case of Bahay Nakpil-Bautista"	680	Appropriation and appreciation of Austrian and Indonesian puppetry	763
A novel offloading insole system designed for healthcare	681	Reinventing the gastronomic experience: using interactive digital environments to raise awareness of food-related cultural heritage	766
Towards an embodied expression of pandemic nodes & networks in the age of social distancing	682	Developing cultural heritage sustainability from the perspective of participatory sentimental souvenir design	770
Cumulus Phd network	683	How does design intervention promote sustainable rural transition: an analytical framework based on the multi-level perspective model	774
Evolution of 'Mashrabiya' in the Middle East & North Africa - traditional wood carving technique revival	684	Designing future hybrid creative space using digital tools in educational institutions and organizations	777
Exploring the potential of material innovation to revitalize traditional crafts in Egypt	687		
An overview of design suggestions for contemporary theatrical VR productions	690	Reviewers	781
Polymath interpolation in transdisciplinary open-ended design – design for conservation	693		
Implementation of design culture as a strategic innovation through design-oriented industrial conversion and product diversification	696		
Sustainable transformation of age-friendly community centres based on transition design	700		
Parametric Joinery. Development of a system of configurable joints	704		
Designing a ward inventory for a sustainable healthcare. Framework for healthcare providers of configurations among disposable medical devices, clinical procedures, and medical equipment in the neonatology department.	707		
A safe space of creativity-designing with vulnerable female communities	711		
The direction of wayfinding. From the identification of a place to the expression of its meaning.	715		

Biophilic design for remote studying environments: analysis of case studies involving a collaboration between ergonomics and environmental psychology



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Abstract

In our post-industrial society, although the remarkable technological advancement allows us endless possibilities, the maturity of the debate on environmental sustainability requires new design, production and consumption strategies, and a radical revision of the concept of development. Our lifestyles increasingly lead us to spend much of our time indoors, and this condition, exacerbated by conflicts and pandemic, has turned the spotlight on the importance of accessibility to the natural environment, put in risk by growing urbanization and global urban population, the upscaling of environmental degradation and the challenges posed by climate change. In this context, Designers are challenged to question new ways of establishing connections with nature that will contribute to mitigate, cope, and adapt to environmental and societal challenges while at the same time helping people to develop new capabilities in their given contexts. Biophilic Design emphasizes the need to maintain, enhance and restore the beneficial experience of nature in the built environment. Even if it's based on scientific evidence from several studies in the fields of psychology, medicine and social sciences, which demonstrate that exposure to natural environments or related elements has a positive impact on human health, further reflections are needed on how these inputs can be embodied in environments and artifacts by the Design disciplines. Based on these assumptions, the theme of the Psychology and Cognitive Ergonomics course within the bachelor's degree program in Industrial Design at Sapienza University of Rome was developed. Through an interdisciplinary approach Human-Centred Design and Environmental Psychology were combined to enquire about the use of biophilic elements within remote studying environments, a widely used practice following the closures of schools and universities caused by the Covid-19 pandemic. A combination of methods and tools from both disciplines were used to test Biophilic Design hypotheses that, on the one hand, ensure optimal ergonom-

ic usability and, on the other hand, through their regenerative qualities, promote psychological well-being and reduce stress symptoms related to remote study activities and social isolation. The analysis of these case studies allowed us to reflect on Biophilic Product Design and their role in remote studying environments. We conclude by advocating the use of interdisciplinary practices in which Design, combined with Environmental Psychology becomes a promoter of more desirable domestic environments and of a future in which a symbiotic relationship with nature is established.

Author keywords

Biophilic Design, Human-Centred Design, Remote Studying, Environmental Psychology

Introduction

The growing urbanization and the continuous increase of the world's urban population have led to a direct and indirect (McDonald et al., 2020) impact on biodiversity (Turner et al., 2004). Environmental degradation and the challenges of climate change make access to greenery and nature a restricted privilege. In today's 'indoor generation,' most human activities occur within an enclosed space (Kelly & Fussel, 2019). This condition has been further exacerbated by the conflicts our society is experiencing and the global pandemic. Following the drastic incidence of Covid-19 since March 2020, the Italian government has implemented strict measures to stem the pandemic spread through rigid lockdowns. Since the pandemic, the world of work has radically changed, with a massive reliance on remote working for all those activities that did not require an unavoidable work presence. However, one of the areas most affected by the implementation of restrictive measures was the educational sector. All Italian schools and universities were forced to implement distance learning (e-learning or remote learning) throughout the most acute phase of the emergency. This forced transition has

entailed not only a restructuring of teaching methods, now characterized by the unavoidable use of digital technologies and means of communication (such as Zoom, Teams, Meet, etc.) but to a complete restructuring of home environments, now dedicated to the activity of studying or working remotely. In addition to this, of course, one of the main consequences of lockdowns has been the inability to leave except for stringent reasons (Corley et al., 2021; Dzhambov et al., 2021), thus limiting people's ability to have contact with natural environments (e.g., Garrido-Cumbrera et al., 2022; Mintz et al., 2021). Therefore, finding strategies to implement natural elements within the home environment became necessary.

The biophilia theory and biophilic design

The term "biophilia" can be summarized as "the innately emotional affiliation of human beings to other living organisms" (Wilson, 1993, p. 31). The concept was introduced by Erich Fromm (1964/1976) and has been popularised in the work of Kellert & Wilson (1993), who affirm that human evolutionary history has produced "the innate tendency to focus on life and lifelike processes" and the need to "affiliate with other forms of life". Biophilia has been conceptualized as a sign of mental and physical health, with supporting evidence showing that natural settings (compared to built settings) are preferred and lead to positive health outcomes, such as restoration from mental fatigue and stress. Building on the theory of biophilia, the biophilic design seeks to use nature in the design of indoor and outdoor environments (as well as in the design of artifacts) to promote people's health and well-being. Biophilic Design stresses the need to maintain, improve and restore the beneficial experience of nature in the built environment. It represents a sustainable approach with financial advantages across healthcare, education, retail, workplace, and community environments (Browning et al., 2012). Kellert & Calabrese (2015) have proposed design strategies for successfully applying biophilic design in diverse contexts, such as educational settings (Alves, Betrabet Gulwadi & Nilsson, 2022). The basic components of the biophilic design framework are: direct (e.g., having indoor plants), indirect experience of nature (e.g., watching nature), and the experience of space and place (e.g., prospect and refuge). Drawing from empirical evidence, biophilic design patterns are not formulas; they are hypotheses to be tested and should be thought of as another tool in the designer's toolkit - meant to inform, guide, and assist in the design process (Ryan et al., 2014).

The psychological impact of biophilic design

Biophilia is one of the aspects most touched upon in the study of this predisposition concerns the natural elements directly or indirectly experienced by the individual. The positive effect of exposure to natural environments and stimuli in promoting psychological well-being has been widely studied (Bratman et al., 2019). The term restoration refers to the recovery or regeneration of mental resources used in daily activities (Harting, 2004). The two main theories concerning restorativeness are the attention restoration theory (ART; Kaplan & Kaplan, 1989), according to which natural environments do not require direct attentional effort, thus allowing for a reduction in the use of cognitive resources (Jiang et al., 2020), and the stress recovery theory (SRT; Ulrich, 1983), which draws on a psycho-evolutionary perspective, and postulates that the natural environment allows for a reduction in arousal and

stress levels (Chang et al., 2021). Direct experience in natural environments is not the only strategy to activate the regenerative process. Implementing natural elements (real or reproduced) in indoor environments through biophilic design can allow one to experience effects similar to those activated by immersion in natural environments. Natural or artificial light with similar characteristics, implementation of natural materials such as wood or stone, natural sounds, and implementation of indoor plants or other reproductions of natural environments are just some of the elements most frequently found in the literature (Bolten & Barbiero, 2020; Browning et al., 2014; Kellert, 2008; 2018; Sturgeon, 2017). Research based on the implementation of biophilic design has reported results consistent with the literature on restorativeness in natural environments (Aristizabal et al., 2021; Cole et al., 2021; Determan et al., 2019; Jiang et al., 2021; Yin et al., 2020), thus confirming the possibility of being able to effectively integrate these types of elements into built and indoor environments as well, with positive effects on psychological well-being.

Aim of the study

Based on these assumptions, this paper intends to report an empirical study promoted during the Psychology and Cognitive Ergonomics course within the bachelor's degree program in Industrial Design at Sapienza University of Rome. Through an interdisciplinary approach, Human-Centred Design and Environmental Psychology set out to promote the use of Biophilic Design to improve remote studying environments, a widely used practice following the closures of schools and universities caused by the pandemic by Covid-19. The aim is to illustrate a possible methodology within Design education and to bring to greater maturity the reflections on Biophilic Product Design to extend our scientific community's knowledge and promote interdisciplinary practices.

Method

Participants

The research sample comprised 521 college students from different Italian universities who voluntarily completed the questionnaire. They were aged 18 to 38 ($M = 20.93$; $SD = 2.20$); 232 were men (44.5%), 282 were women (54.1%), and 7 preferred not to answer (1.4%). 466 students were enrolled in a bachelor's or single-cycle degree program (89.4%) and 55 in a master's degree program (10.6%).

Tools and procedure

The research was conducted in full compliance with the Ethical Principles of Psychologists and Code of Conduct of the American Psychological Association (APA) and was authorized by the Ethics Committee of the Sapienza University of Rome. The study was conducted in April 2022, when Italian universities, due to the Covid-19 pandemic, continued implementing a hybrid teaching mode with in-person and remote lectures. During an initial administration, participants were asked to think about the home environment where they performed their remote study activities (didactic or self-study) and to complete a self-report questionnaire. The first instrument was the Perceived biophilic qualities in remote studying (ad hoc): the measure includes 19 items referred to the main sources of Biophilia found in the literature (e.g., Bolten & Barbiero, 2020; Browning et al. 2014; Kellert, 2008; Kellert 2018;

Table 1. escriptive statistics, bivariate correlations and Alpha in diagonal. Descriptive statistics, bivariate correlations and Cronbach's Alpha in diagonal.

Variable	N	M	SD	S	K	1	2	3	4	5	6	7
1. General Perceived Biophilia	521	3.20	.61	-.03	-.01	.81						
2. Direct Experience	521	3.65	.69	-.36	-.01	.89***	.81					
3. Indirect Experience	521	2.39	.81	.43	.02	.58***	.22***	.88				
4. Prospect and Refuge	521	3.19	1.23	-.02	-.86	.73***	.60***	.15***	.72			
5. Restorativeness	521	3.27	.72	-.18	.12	.41***	.36***	.25***	.25***	.72		
6. Engagement	521	4.43	.95	-.39	.17	.18***	.15***	.12**	.12**	.26***	.88	
7. Stress	521	2.35	.41	.16	.36	-.08*	-.10*	-.04	-.02	-.18***	-.08	.75

Note: * = p < .05; ** = p < .01; *** = p < .001; M = Mean; SD = Standard deviation; S = Skewness; K = Kurtosis.

Sturgeon, 2017) divided into the 3 categories identified by Kellert and Calabrese (2015), namely direct experience with nature (10 items; Alpha = .81), indirect experience (6 items; Alpha = .68), and the experience of space and place (3 items; Alpha = .88). Also, an overall perceived Biophilia score was calculated (Alpha: .82). The psychological variables concerned Perceived restorativeness (5 items; Alpha: .72; Korpela et al. 2008), Student Engagement (UWES-9; 9 items; Alpha: .88; Schaufeli & Bakker, 2003; 2004), and Student Stress - Effort-Reward Imbalance student questionnaire (12 items; Alpha: .75; Wege et al., 2017) For all these measures, the response scales consist of a 5-step Likert scale (from 1 = "Completely disagree" to 7 = "Fully agree"), except for the Engagement rating scale, for which a 7-step Likert from "never" to "always" was used. Socio-demographic data (gender, age, and degree course level) were also collected. The same participants were asked to fill out a second questionnaire containing an ergonomic checklist for objectively assessing all the biophilic elements with which they relate, directly or indirectly, during remote studying activity and that, therefore, could contribute to their satisfaction and requirements needs related to certain needs classes such as Safety, Well-being, Usability, Appearance, Management (UNI 8289:1981). For each requirements class, the requirements classes have been identified (UNI 8290-2:1983) to which the items of the Checklist refer by proposing questions for the verification of the qualitative and quantitative characteristics of the elements observed, starting from minimum inclusive safety performance (Villani et al., 2021) thresholds defined by regulatory references related to health and safety at work agile (L. n. 81/2017, art. 18-23), to the usability (D.M. 236/89) and from "good technique" criteria correlated with people anthropometric data.

Results

Relationship between perceived biophilic qualities and psychological variables

Jamovi v.2.2.5 statistical software was used to analyze frequencies, descriptive statistics, and correlations among psychological variables. The mean scores, univariate normality, and bivariate correlations between the variables under research are shown in Table 1. According to the skewness and kurtosis values, which are all between -1 and +1, the normality assumption was not violated. From the correlation analysis, the overall indicator of perceived Biophilia was found to be correlated with perceived restorativeness (r = 0.41; p < .001), engagement (r = 0.18; p < .001), and stress (r = -0.08; p < .05), demonstrating how the perception of natural elements can help regenerate

students' cognitive resources, promoting their engagement in the educational activity, by reducing stress-related symptoms. Regarding the specific sources of Biophilia, direct experience of natural elements, whether internal or external to the study environment, reported the highest correlation indices, correlating positively with restorativeness (r = 0.36; p < .001) and engagement (r = 0.15; p < .001) and negatively with stress (r = -0.10 < .05). Indirect experience with nature, prospect, and refuge reported same correlation indices with restorativeness (r = 0.25; p < .001) and engagement (r = 0.12; p < .01). Unexpectedly these two sources of perceived biophilia did not correlate with perceived stress (r = -0.04; p = n.s.) (r = -0.02; p = n.s.).

Objective perception of biophilic-related elements

The ergonomic checklist results about biophilic elements have been analyzed on three levels: biophilic elements in general (one general index), level of individual needs classes (6 indices), and level of individual requirement classes (15 indices). Each of these three refers to the individual elements of

Table 2. Ergonomic checklist results about the biophilic element

Class	Yes	No	NR
Needs class - Security	32%	57%	11%
Requirement class - Fire safety	30%	58%	12%
Requirement class - Safety of use	34%	56%	10%
Needs class - Well-being	35%	36%	29%
Requirements class - Thermal comfort	41%	21%	37%
Requirements class - Acoustic well-being	28%	55%	17%
Requirements class - Visual well-being	51%	38%	11%
Requirements class - Olfactory well-being	46%	47%	7%
Needs class - Usability	45%	37%	18%
Requirements class - Accessibility	14%	56%	30%
Requirements class - Furnishability	58%	23%	19%
Requirements class - Furnishability	58%	23%	19%
Requirements class - Flexibility	41%	50%	9%
Requirements class - Usability	45%	40%	15%
Requirements class - Communicativeness	84%	9%	7%
Needs class - Appearance	41%	47%	12%
Needs class - Privacy	38%	49%	13%
Requirements Class - Spatial Privacy	55%	31%	14%
Requirements Class - Functional Privacy	20%	66%	14%
Needs class - Management	77%	16%	12%
Requirements Class - Maintainability	65%	22%	13%
Requirements Class - Cleanability	79%	10%	11%

the checklist that, aggregated, return these summary indices. Generally, it has emerged that inside the remote study sites/workstations, there are no biophilic elements in 40% of cases inside the remote study sites/workstations. The results of the other two levels are shown in Table 2.

Examples of biophilic design

The psychological and ergonomic results were subsequently considered as a basis for developing the design proposals. The ergonomic approach to the project, with its ability to evaluate the multiplicity of variables that define the interaction between people and what they relate to (Tosi, 2018), has been combined with the philosophy of Human Centered Design. The biophilic design solutions presented by students vary in the use of materials, shapes, and textures in their aim to stimulate sensory perception, improve well-being and meet ergonomic requirements. Moreover, to prevent the solutions of these new designers from being replaced by superficial imitations, a more holistic and sustainable approach has been stimulated (Stevens et al., 2020), promoting the use of solutions respectful of Nature and also from the point of view of materials and production processes.

The data collected by the Ame group showed that as the appearance variable increases, the level of perceived stress decreases while the person's interest increases. On the other hand, an increase in olfactory well-being, linked to air quality, leads to a psychological reduction in stress. Finally, good usability within the smart studying workplace positively influences the subject's performance, increases well-being and engagement, and reduces stress and burnout. They proposed a cactus-shaped desk module that performs several functions, including tidying up cables, pen holders, and air freshener. This product is intended to improve classes of needs such as Safety, Wellness, Usability, and Management, stimulating the perception of natural elements on different sensory levels. The material they use for production is Ecoallene, derived from the processing and recycling of poly-bonded waste, which is colorable, versatile, infinitely recyclable, and suitable for various types of molding.

Instead, the Palma group, in order to improve their situation, worked on the correlation of ergonomic well-being on mental and physical health and on how colors and materials reminiscent of nature increase the sense of belonging to a place and, consequently, the desire to spend more time there. So they designed Ceppo, a footrest whose materials and shapes recall a tree trunk. In particular, it improves the ergonomics of the study station and stimulates sight and touch during the remote study activity through natural materials such as wood and stabilized lawns.

The Cinquis group started from the point of view of implementing acoustic well-being, usability, appearance, and safety, which were found to be lacking in the questionnaire, and from the psychological point of view, improved direct experience with nature, in particular through sound, because of the direct effects they have on restorativeness and engagement. They worked on evoking nature at a sound level, designing a speaker that recalls the organic shapes of a shell, also associating on a semantic level the act of bringing the shell to the ear to listen to the sea. In addition to reminding marine environments, the speaker emits white noises that stimulate concentration during one's study time.



Figure 1. Jungle-IT by Marmotas, rendering

In the last case, however, the ergonomics checklist showed that visual comfort, usability, accessibility, and flexibility were lacking, so they implemented them in their remote studying station. From a psychological point of view, they instead worked on enhancing the indirect experience with nature through shapes and colors, as it increases the organizational potential of the user, the positive relationship between the user and the room, and a general sense of security. So, with the *Jungle-IT* (Figure 1), Marmotas group brings the jungle into the remote study station. The system, consisting of simple elements such as wooden profiles, rope, cork leaves, and S-shaped steel hooks, offers the possibility of a support/shelf where to place books and also serves as a bulletin board, allowing to reorder sheets and notes.

Conclusion

In conclusion, this study shows the positive impact of using natural elements in promoting ergonomic and psychological well-being in remote studying settings. Design, with its ability to act both on a micro- and macro-scale, can encourage the implementation of biophilic elements, particularly in those contexts where direct contact with green spaces has been diminished, such as in large cities or metropolises, but also extreme context like the Fourth Environment. It can help to cope with traumatic and unpredictable events, such as the Covid-19 pandemic and conflicts, that makes immersion in green spaces difficult. The collaboration between two different perspectives, such as Psychology and Design, shows how Biophilic Design can be put into practice: it allows both the analysis of objective requirements for design and the consideration of students' subjective needs and perceptions. The benefit of this interaction is that it allows the construction of more desirable remote studying environments centered on humans and their real needs and a symbiotic relationship with nature. Biophilia alone is not enough to generate automatically sustainable solutions in this context. It is therefore important to provide constant input to students on how to make this reconnection with nature not only aesthetic but the result of a conscious practice at every level. To face today's challenges, using the green "as a sole legitimization of an otherwise unsustainable project is not enough," as Celine Baumann states (Block, 2019). There is, therefore, a need to find more holistic and enlightening solutions by broadening the scope and examining the challenge in a wider context and at different scales (Scalisi & Ness, 2022). Developing a new unity with nature is necessary, a paradigm shift from "human on nature" to "human and nature".

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This book contains academic papers and posters of the Cumulus Antwerp conference, held in Antwerp on 12-15 April 2023. The Cumulus community, designers, artists, and educators were invited to submit contributions on how culture and creative industry can offer resilience, consolation, and innovation models on human scale, in line with the conference theme 'Connectivity and Creativity in times of Conflict'.

The contributions were double blind reviewed in the tracks

- 1) Nature positive/Design for transformation,
- 2) Digital futures/Hybrid reality,
- 3) Handle with care/Inclusivity, and
- 4) PhD network.

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