[D2.2 Design and Implementation Report]

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ABSTRACT

Deliverable 2.2 – Design and Implementation Report documents the initial design concept and implementation progress of the Biophilic Learning Environment established under Work Package 2 of the LED Education project. This report outlines the design approach, key principles applied, and the selection and integration of elements such as furniture, materials, and plants suitable for the specific spatial and climatic context. Informed by partner consultations and expert input, the design prioritises learner well-being, sensory engagement, and flexibility for hybrid use. The deliverable also reflects physical implementation. This foundational work supports the broader project objectives to enhance emotional well-being and engagement in digital learning environments.

KEYWORDS

Biophilic design, educational environment, hybrid learning environment, learner well-being, implementation

DISCLAIMER

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Table of content

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Executive Summary

This report documents the design and implementation of the LED Education biophilic hybrid learning space (D2.2, WP2). The objective was to transform a modest summer camp facility into a multifunctional, emotionally responsive environment that supports hybrid learning for digitally enrolled students. The space was designed to mitigate known challenges of digital education – such as isolation, cognitive fatigue, and lack of hands-on learning – while promoting emotional well-being, autonomy, and academic engagement.

The learning hub integrates principles from pedagogical psychology, biophilic design, and Universal Design for Learning. Key features include modular furniture, individualised lighting, quiet retreat zones, collaborative work areas, a creative play corner, and a fully equipped kitchen for interdisciplinary tasks. Special attention was given to flexible use of space, sensory diversity, and student choice – creating an inclusive and learner-centred environment.

The design was developed collaboratively with educational experts from Tallinn University (TU) and implemented in consultation with tutors, interior designers, and pedagogical staff. All materials and layouts were selected to be scalable, cost-efficient, and adaptable to small spaces, ensuring replicability in other educational settings across Europe.

As part of the ongoing project, further enhancements, including a living plant wall and integrated digital tutor tools, will be co-developed with students during the WP5 piloting phase. Monitoring environmental and behavioural feedback will inform future refinements.

This report demonstrates that implementing a research-informed, emotionally intelligent, and biophilic hybrid learning space is both achievable and impactful, even within modest physical and financial constraints.

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List of Abbreviations and Acronyms

D	Deliverable
MS	Milestone
WP	Work Package

Partner short name

HAW	Hochschule für Angewandte Wissenschaften Hamburg
TLU	Tallinn University
ElizaBuild	SIA ElizaBuild
Aiedu OY	AIEDU OY

List of Figures

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1. Introduction

The design and implementation of the biophilic learning space under WP2 is grounded in the broader vision of the LED Education initiative: to reimagine educational environments through a learner-centred, emotionally intelligent, and digitally supportive lens. As digital education becomes increasingly central in formal learning structures, concerns about student well-being, motivation, and engagement have grown. This is especially true for young learners, for whom physical environment plays a significant role in shaping emotional safety, cognitive performance, and social development.

The COVID-19 pandemic further amplified the disconnect between students and learning spaces, highlighting the emotional fatigue and social isolation caused by prolonged screen exposure and non-interactive environments. In response, this project aimed to provide not only a digitally equipped hybrid education space, but also an emotionally restorative space guided by biophilic design principles.

Biophilic design, defined as the intentional integration of natural elements into built environments, has been demonstrated to significantly reduce stress, improve concentration, and foster cognitive development in learning settings (Kellert & Calabrese, 2015; Barrett et al., 2015; Leif & Loftness, 2024). For this reason, WP2 focused on translating these scientific insights into a physical learning space that would enhance emotional well-being while supporting hybrid education delivery.

1.1 Purpose of the document

The purpose of this D2.2 is to document the design and implementation process of the biophilic learning environment established under WP2 of the LED Education project. This space forms the physical and pedagogical foundation for future pilot activities planned under WP5 and is key to delivering a hybrid educational model that supports digital well-being, emotional development, and learner autonomy.

This report specifically focuses on two core outcomes of WP2:

- Set Up of Classrooms, Communal, and Specialised Areas (Task 2.3). The rented educational space was equipped and zoned to support diverse learning styles – from focused digital work to collaborative and creative tasks. Furnishing, layout planning, and flow design were informed by learners' age-specific needs, starting from 10 years and upwards. The final setup includes workstations, communal areas, breakout zones for emotional regulation, and adaptable teaching spaces.
- Implementation of Biophilic Design Features (Task 2.2). Following Kellert's biophilic design framework, the learning environment integrates natural elements – such as light, greenery, wood textures, and nature-inspired visual motifs. These features were chosen to foster emotional safety, improve attention, and support cognitive and emotional engagement, particularly important for children learning in hybrid or digital formats.

Additionally, the space has been developed with the following strategic intentions:

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- Support Emotional Intelligence and Digital Autonomy. The environment supports activities that develop learners' emotional intelligence and time-management skills. It includes soft seating, sensory modulation areas, and creative zones that will host tutor-led well-being sessions and student-centred support routines in WP5.
- Enable Adaptation and Replicability Across Europe. The design serves as a replicable prototype that other educational institutions – particularly public schools – can adapt using cost-effective biophilic and learner-centred principles. This supports the long-term goal of influencing education policy and infrastructure development at the European level.

The subsequent D2.3 Compliance and Certification Report will address the formal documentation of EU regulation alignment and legal certification.

Following the space inauguration, pilot interventions under WP5 will begin, testing the educational routines and digital well-being strategies developed in WP3 and WP4.

2. Design Concept and Approach

The learning space implemented under WP2 is a flagship example of the LED Education project's commitment to transforming educational practice through space design. Rooted in the vision of merging hybrid education with biophilic principles, this environment is not just a physical classroom – it is a pedagogical tool designed to promote inclusion, emotional regulation, digital fluency, and student autonomy.

The design serves two core purposes:

- Hybrid Support Hub: It acts as a welcoming, adaptable space where students engaged in various digital or online schooling formats can gather, receive tutoring, and access emotional support. The environment encourages multi-age peer interaction, personalised learning, and reduced isolation – key issues identified in the project's needs analysis.
- Scalable Prototype: Beyond its immediate function, this space serves as a model environment for replication across Latvia and other EU countries. It demonstrates how architectural design – through natural materials, sensory zones, and flexible learning stations – can contribute directly to student well-being and cognitive engagement.

This interdisciplinary approach draws on:

- Biophilic architectural design (natural light, organic materials, indoor greenery);
- Pedagogical psychology (zones for emotional decompression and self-regulation);
- Transformative learning theory, which sees the space not only as a backdrop but as an active element in shaping learning experiences.

Deeper research insight on the design concept is reflected in the D3.1 Research Report on Educational Methodologies.

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2.1 Hybrid Learning Rationale

Hybrid learning environments – integrating both online and face-to-face modalities – are increasingly recognised as optimal models for 21st-century education. This blended approach addresses several shortcomings of purely digital learning, such as lack of social interaction, limited emotional support, and challenges in delivering hands-on or practical learning.

Numerous studies demonstrate the benefits of hybrid models in improving both learning outcomes and student engagement. Hybrid education facilitates greater personalisation, allowing students to progress at their own pace while still benefiting from real-time support and feedback (Schmid et al., 2023). The physical presence of tutors and peers also fosters a collaborative learning atmosphere that supports socio-emotional development – particularly important in the critical ages.

In school-aged learners, research suggests that hybrid environments promote digital competence and emotional resilience. For example, a study across multiple European secondary schools found that students in hybrid settings developed stronger digital literacy skills and reported higher well-being scores than their peers in fully online formats (Loukianova et al., 2023).

Moreover, hybrid models reduce digital fatigue and isolation by providing physical spaces for structured routines, human connection, and peer interaction – components proven to buffer against stress and learning disengagement (Sun et al., 2022). These effects are even more pronounced when learning environments are designed to be biophilic and emotionally supportive, as implemented in the LED Education.

In this context, the LED Education hybrid learning hub functions not only as a classroom but as a restorative and empowering ecosystem. It is specifically designed to balance screen-based instruction with human-centred pedagogy, addressing the dual imperatives of academic mastery and emotional well-being. The inclusion of physical tutors and emotionally intelligent design elements ensures that education is not just accessible but also psychologically sustainable and developmentally appropriate.

2.2 Biophilic Design Integration

The physical learning environment of the LED Education was designed using biophilic principles, an evidence-based framework that enhances human well-being by integrating natural elements into interior spaces. This approach addresses an urgent educational challenge: how to create emotionally supportive and cognitively nourishing environments for students increasingly immersed in digital learning systems.

Biophilic design contributes significantly to stress reduction, attention restoration, emotional regulation, and academic performance in children and adolescents (Barrett et al., 2015; Yin et al., 2020; Chawla, 2015). These benefits are particularly valuable in hybrid educational contexts, where students often face digital fatigue, reduced movement, and social isolation.

Following the theoretical model of Kellert and Calabrese (2015), the LED Education space was structured around three key biophilic domains: direct experience of nature (e.g. plants, light),

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indirect experience (natural materials, colours), and nature of the space (spatial configuration, prospect and refuge). This structure guided decisions on furniture, lighting, spatial planning, and sensory design. The implemented elements include:

- Natural Lighting: Maximised through unobstructed windows and adjustable blinds to support circadian rhythms and reduce eye strain.
- Indoor Plants: Locally suitable species were selected to regulate air quality and bring calming natural textures into the classroom.
- Natural Materials and Tactile Surfaces: Use of untreated wood, textiles in earth tones, and organic shapes to foster sensory comfort and familiarity.
- Acoustic Zoning: Quiet areas and semi-enclosed corners provide space for self-paced learning or emotional decompression, supporting neurodiverse learners as well.
- Open Layout and Movement Zones: Designed to facilitate flexible learning configurations, encouraging collaboration, movement, and autonomy.

Students exposed to biophilic environments demonstrate improved concentration, greater satisfaction, and fewer behavioural issues compared to those in conventional classrooms (Matsuoka, 2010; Beute & de Kort, 2014). In the LED education, biophilic design is not merely decorative – it is instrumental in advancing the project's objectives of enhancing emotional intelligence, promoting learner well-being, and creating a reproducible, inclusive model for digital-age education.

2.3 Support for Practical and Emotional Learning

The LED hybrid learning environment was deliberately designed not as a functional academic space, but also as a space for emotionally intelligent education and practical skill development. This dual purpose reflects the project's overarching objective: to nurture well-being and holistic competence in an age range especially sensitive to cognitive-emotional interplay, autonomy formation, and social belonging.

The learning space is underpinned by principles from developmental and pedagogical psychology, operationalised in the following spatial and organisational features:

- Emotionally safe architecture: Quiet zones, decompression corners, and one-on-one tutoring areas were created to support students experiencing cognitive overload or emotional stress, ensuring learners can regulate themselves in a supportive context.
- Structured daily routines: The space is zoned to facilitate a rhythm of the day – alternating between focused learning, creative tasks, and restorative breaks. This structure fosters emotional predictability and cognitive stamina, aligning with findings on routine and executive function development (Diamond, 2013). In accordance with pedagogical guidance from TU, these routines are also designed to balance “screen time” and “green time.” Learners will move between digital engagement and nature-connected or sensory-based activities, helping to reduce digital fatigue and support attention restoration. Quiet

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zones, physical movement, and interactions with biophilic elements (e.g., plants, natural textures) are embedded into the daily flow, reinforcing emotional self-regulation and maintaining cognitive energy throughout the day.

- Multimodal learning configurations: Tables and seating arrangements were modular to support transitions between solo reading, peer group discussions, collaborative projects, and hands-on experimentation – supporting a Universal Design for Learning philosophy (CAST, 2018).

These principles directly respond to the social-emotional learning needs identified in WP3 and reaffirmed by TLU's analysis. A psychologically responsive environment has been shown to increase engagement, reduce behavioural disruptions, and promote higher-order thinking skills, particularly in vulnerable or digitally fatigued learners (Goldstein & Brooks, 2007; Hattie, 2012).

The LED space encourages learners to co-construct knowledge actively. Tutors act as facilitators, supporting not only academic goals but also emotional development, resilience, and agency. Biophilic and flexible elements contribute to a calm, engaging environment conducive to self-regulation – an important developmental process in adolescence (Blakemore, 2018).

2.4 Transformative Education and Self-Directed Learning

The LED learning hub is intentionally designed to empower students as active, reflective participants in their own educational journey. The physical and pedagogical architecture of the space fosters self-directed, inquiry-based, and emotionally supported learning, especially suited to the developmental needs of diverse age students in digital education.

Rather than centring instruction around a teacher, the space supports the co-construction of knowledge between students and tutors – who serve as facilitators, not instructors. The layout and tools encourage learners to explore independently, collaborate voluntarily, and reflect regularly.

Key Features That Foster Autonomy:

- Modular desk layouts allow fluid transitions between solo work, peer discussion, and collaborative tasks – encouraging learners to choose their ideal working mode.
- Accessible resources such as educational games, prompts, and digital devices enable students to initiate learning without waiting for permission or instruction. Tutors assist by helping students find educational games or platforms aligned with their study goals.
- Tutor anchor points are placed for discreet support – allowing students to seek help or feedback while retaining agency.
- Zoning with choice lets learners choose spaces (quiet, social, creative) based on emotional readiness and task complexity – building self-awareness and self-regulation.

This approach is grounded in transformative education theory, which emphasises the role of critical reflection, emotional development, and choice in shaping identity and motivation. It also aligns with research showing that autonomous learning correlates with increased motivation,

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digital competence, and emotional resilience (Zimmerman, 2002; Ryan & Deci, 2017; Luo et al., 2022).

By promoting ownership, emotional intelligence, and flexible learning paths, the space prepares students not only to succeed academically, but also to adapt to complex social and digital futures.

3. Implementation of Design Features

The implementation of the LED Education biophilic learning environment took place between Month 2 and Month 4 of the project. It was developed in close alignment with the pedagogical concept outlined in Section 2 and grounded in interdisciplinary collaboration across partners and experts.

From the earliest stages, the suitability of the chosen educational space was reviewed with project partners, including researchers from TLU. Their pedagogical and psychological insight helped confirm that the space was fit for the project's intended purpose. Based on their feedback, several adjustments and enhancements were integrated into the design process.

Recognising that the space could not accommodate individual quiet booths for all learners, the team adopted TLU's suggestion to create semi-enclosed "nests" using furniture and zoning, alongside the purchase of high-quality headsets to enable students to work in parallel without distraction. The need for a designated area for collaborative activities, such as workshops, was also addressed by allocating part of the room for flexible group use, equipped with a large display screen to support hybrid sessions.

Following TLU's recommendation, an interior designer was engaged to ensure that spatial planning and sensory layout would be optimised to balance natural elements with the cognitive and emotional needs of students. TLU also advised the team to consider incorporating a telepresence robot to enable remote tutoring support in the future – an idea that is currently under evaluation for piloting. Additionally, the importance of maintaining spare digital equipment such as computers and headsets was acknowledged and integrated into the procurement plan to ensure reliability during daily operations.

Pedagogical guidance was provided by Elizabuild's internal expert, Svetlana Osinceva, a PhD candidate in E-learning and Educational Technology, whose insights supported the alignment of physical features with emotional development and learning autonomy. Tutors and support staff contributed to shaping layout details based on their anticipated daily interactions with students, offering practical feedback.

Through this coordinated process, the design implementation addressed both the compliance requirements of WP2 and the pedagogical vision for future WP5 piloting. The final setup is tailored to support students enrolled in various forms of digital schooling, offering an emotionally supportive, sensory-rich, and cognitively engaging environment.

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3.1 Classroom and Communal Area Setup

The transformation of the premises – originally used for summer camp activities – into a hybrid biophilic learning environment was a critical step in aligning the physical space with the pedagogical goals of the LED Education project. The objective was to establish a multifunctional educational space that supports digital learning, social interaction, emotional well-being, and practical engagement for students from various grade levels enrolled in online schools.

Although the space is modest in size, careful spatial planning and thoughtful zoning made it fully suitable for hybrid education. The implementation proves that hybrid-biophilic learning environments do not require large or high-budget facilities. This model can be feasibly replicated by schools and institutions in other regions, even with limited space and financial resources, making it a practical and sustainable example of inclusive educational innovation.

The design logic was based on a deep understanding of the limitations of digital-only learning environments, including digital fatigue, social isolation, limited feedback, and the lack of practical, hands-on experiences. These challenges informed the creation of a diversified classroom structure composed of several functional zones, in accordance with Task 2.3.

Focused Study Desks. Workstations were equipped with task lighting, modular desk units, and seating to support deep digital engagement (See Photos 1 and 2). To reduce distraction and promote individualised learning, high-quality soundproof headsets with built-in microphones were procured in multiple formats (e.g. over-ear, wireless, wired, and in-ear models). Each student will be assigned a personal headset, promoting hygiene and comfort. Spare laptops and accessories are also available to ensure digital equity for students who may lack or forget their devices.

Figure 1. Photos 1 and 2 – Flexible Learning and Communal Zone

Lighting Adaptation. Each workstation includes adjustable lamps with customisable luminance and colour temperature settings, allowing students to personalise their micro-environments for optimal comfort and focus – particularly relevant given the screen-intensive nature of hybrid learning.

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Interactive Learning Zones. Mobile furniture and flexible layouts facilitate smooth transitions between individual, paired, and group activities. These spaces are vital for supporting the practical dimension of learning that is often diminished in online-only education. For example, tables can be easily reconfigured to enable collaborative experiments, creative workshops, or hands-on projects, thus restoring the tactile and experiential components of learning.

Group Dialogue and Presentation Area. A comfortable media zone with beanbags and projector can host storytelling sessions, multimedia learning, and peer presentations (See Photo 3). Ring lighting was installed to enable high-quality video recording and feedback, supporting both hybrid teaching and student reflection. This zone also supports the peer socialisation aspects of learning that are critical for emotional development and academic engagement.

Figure 2. Photo 3 – Emotional Support & Movement Zone

Kitchen and Communal Space. A dining area fosters student autonomy and well-being through shared snack times and informal social interaction (See Photo 4). Beyond its social value, the kitchen will serve practical purposes for home economics-style assignments and project-based learning. Meals are planned in collaboration with a certified food service provider, adhering to national food safety regulations.

Figure 3. Photo 4 Multi-Use Relaxation, Dining, Study, and Game Zone

Monitoring and Feedback Infrastructure. Tutors will be equipped with tablets for logging student attendance and daily activities. These digital records will be integrated with the feedback and reflection tools being developed under D3.3. This infrastructure allows for

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consistent monitoring of student engagement and supports the provision of real-time guidance and emotional support.

Pedagogical Justification. This space design responds to several documented barriers in digital education:

- Social isolation and its impact on mental health (Hunukumbure et al., 2021);
- Academic dishonesty in remote learning (Integrity in Education Project, 2020);
- Insufficient feedback cycles and disengagement (Leibold & Schwarz, 2022; Li, 2022; Hibert et al., 2023);
- Exclusion of practical subjects and hands-on learning in online formats (ISTE, 2020; GFEL, 2022).

By creating a physical environment tailored to mitigate these challenges – even in a relatively compact space – the LED Education classroom setup serves as a replicable model for other schools. It demonstrates that meaningful innovation in hybrid learning can be achieved with strategic design choices and limited infrastructure, without large-scale renovations or high recurring maintenance costs. This reinforces the project's core values of inclusivity, scalability, and sustainability within the European education landscape.

3.2 Biophilic Design Implementation

The biophilic design of the LED hybrid learning hub was developed to support learner well-being, emotional stability, and attention restoration – particularly important in hybrid digital education environments. Drawing on research from design science, environmental psychology, and educational theory, the space was structured to engage learners' senses, provide emotional grounding, and foster a sense of belonging and safety.

The implementation followed the biophilic design dimensions outlined by Kellert and Calabrese (2015), which include direct experience of nature, indirect experience of nature, and spatial qualities that evoke a connection to natural systems.

Natural Light and Open Views. A deliberate choice was made not to obstruct windows with large plants or bulky furniture in order to preserve access to daylight and outside views. Maximising natural light not only supports visual comfort and circadian rhythm regulation but also reduces cognitive fatigue – a common issue in screen-heavy educational environments.

Living Plants and Green Elements. Potted plants and vertical greenery were distributed throughout the space to provide direct interaction with natural forms. The plant species were carefully selected based on their tolerance to the available light conditions in the classroom, ensuring long-term maintenance and visual impact. In line with psychological research (Leif & Loftness, 2024), this greenery fosters attention restoration, reduces stress, and contributes to a calming atmosphere.

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To deepen the sense of connection and ownership, a 'living wall' will be co-created with students. installation will serve both as a symbolic and functional biophilic element, reinforcing community, continuity, and responsibility.

Nature-Inspired Seating and Retreats. Hanging chairs were installed to create small retreat spaces where students can sit alone, reflect, or engage in independent learning. These chairs simulate the sense of being outdoors – swaying gently, cocooned in fabric – and provide an emotionally safe zone. Their positioning near plants strengthens the immersive natural effect.

Natural Materials and Textures. Furniture and fittings feature natural materials such as untreated wood, wicker, and stone-textured surfaces. These tactile elements foster comfort, reduce overstimulation, and encourage sensory connection – particularly beneficial for neurodiverse learners.

Colour Palette and Adaptive Lighting. The colour scheme was intentionally limited to earth tones and sky tones, avoiding harsh synthetic hues. These visual cues help maintain emotional stability and mental focus. Floor lamps with adjustable brightness and colour warmth were installed to allow students to modify their lighting environment according to their needs and sensitivity. This flexibility supports autonomy and comfort during long study sessions.

Ventilation and Air Quality Monitoring. To ensure a healthy indoor environment, a CO_2 detector was installed to monitor air quality. This tool allows tutors and staff to respond promptly when fresh air is needed, minimising cognitive fatigue and improving learner alertness.

Nature-Inspired Wall Murals. Visual design elements such as mountain motifs and botanical illustrations were added to the walls. These features contribute to a visual rhythm that enhances relaxation and provides gentle sensory stimulation without distraction. They also support the spatial perception of depth and openness within the compact layout of the room.

By carefully integrating these elements within a small, multi-use space, the LED Education classroom demonstrates that biophilic design is achievable without major renovation or large financial outlay. Each choice was pedagogically and psychologically grounded, contributing to a flexible, inclusive, and emotionally supportive hybrid learning environment. The implementation of these features also ensures that the model is scalable and replicable in other educational contexts across Europe, including schools with limited space or resources.

3.3 Specialised Corners for Emotional Support and Creativity

To support students' emotional well-being and encourage creativity, two dedicated areas were integrated into the learning space. These interventions respond to the need for environments that support both self-regulation and playful, socially engaging experiences – particularly important for learners in hybrid settings, and especially for those who are neurodiverse or younger in age.

Emotion-Focused Nooks. Comfortable hanging chairs positioned near greenery offer semi-enclosed spaces for individual use (See Photo 5 and Photo 3). These nooks provide students with a quiet zone where they can relax, reflect, or work independently in a calm, supportive

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setting. Small side tables accompany the chairs, making them usable both for rest and for focused academic tasks.

Figure 4. Photo 5 – Emotional Retreat and Individual Study Nook

The soft carpeted floor, beanbags, and varied seating options further diversify the space, allowing each learner to choose the environment that best suits their emotional state or learning preference at a given moment. These design choices promote self-awareness and emotional regulation – core objectives of the project's well-being framework.

Creative Play and Movement Area. A separate corner of the classroom is equipped with open shelving filled with board games, tactile objects, and simple interactive tools that invite exploration and informal learning (See Photo 4). This area supports social-emotional development, especially among students who benefit from multisensory learning and movement-based engagement.

Tutors can use this space to interact with students in low-pressure, playful contexts, helping to build trust and increase emotional literacy through shared activities. In particular, this zone is intended to support transitions between learning modes (e.g. from structured academic tasks to relaxation or creativity), which is especially valuable in hybrid educational environments.

An additional feature includes a movement-based play zone located near the media area. Equipped with the game "Just Dance" and connected to the screen and speakers, this setup provides learners with a physical outlet during bad weather or long study sessions. It supports physical activity, peer interaction, and emotional release – important factors in preventing digital fatigue and promoting overall well-being.

4. Conclusion and Next Steps

The LED Education learning space represents an important milestone in developing a scalable model for hybrid, biophilic education that supports student well-being, autonomy, and engagement. While the physical setup is complete, the space is intentionally designed to remain flexible and responsive to evolving educational needs – particularly during the piloting phase under WP5.

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Use During Piloting Phase

The space will serve as the central hub for piloting hybrid learning activities, offering physical support to students enrolled in digital education. During this phase, all lighting configurations and workstation personalisation features will be actively used and tested. The layout allows for adaptive use, with the possibility of minor changes or additions based on tutor and learner feedback. The setup will also enable observations on how biophilic features (e.g. plants, natural textures, sensory spaces) influence learner focus, mood, and participation.

One of the central community-building elements planned is the creation of a **"**living wall**"** in the hanging chair area. This wall will be developed collaboratively with new students as they join the space. Each learner will have the opportunity to contribute a personal plant or select one from a curated collection. This participatory activity aims to strengthen student ownership of the environment and reinforce emotional connection to the learning space.

While the main infrastructure has been successfully implemented, several practical elements will continue to evolve during the course of the project:

- Finalising tutor workspace setup, including integration of attendance tracking and feedback tools. These elements will be developed and tested in coordination with D3.3 to support daily documentation, tutor reflections, and individual learner monitoring.
- Testing and calibrating CO_2 sensors will be carried out during active project use, allowing the team to monitor air quality and adjust ventilation routines in real-time based on occupancy and environmental conditions.
- Establishing plant care routines will also be integrated into the learning process. Students will be gradually involved in maintaining the greenery, reinforcing responsibility, environmental awareness, and daily structure through shared tasks. This will support both the sustainability of the space and the project's emotional development goals.

These ongoing activities will be observed, recorded, and adjusted throughout WP5, ensuring that the learning space remains dynamic, learner-responsive, and grounded in everyday educational realities. Future enhancements may also explore the use of virtual reality (VR) as a bridge between digital and nature-based learning – expanding access to environmental exploration even in urban or indoor settings.

Conclusion

The process of designing and implementing a research-informed hybrid biophilic environment has demonstrated that meaningful educational transformation does not require high-cost or large-scale infrastructure. With thoughtful planning, pedagogical alignment, and targeted investment, even modest spaces can become emotionally supportive, flexible, and inclusive environments that address the challenges of digital learning.

As the project enters its piloting phase, the LED space will be continuously assessed and refined in response to learner needs, environmental feedback (including air quality and lighting), and

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observed patterns of use. These real-time insights will inform the final model to be shared across the Erasmus+ community as a replicable, student-centred innovation.

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Annex 1

Visual Overview of Implementation

The following images document the key spatial zones and design features implemented in the LED Education hybrid learning hub. The photos illustrate how biophilic, emotionally responsive, and flexible-use principles were integrated to support digital-age learners. Each image is accompanied by a caption describing the purpose and pedagogical function of the featured area.

Figure 1. Photos 1 and 2 – Flexible Learning and Communal Zone

This area supports both focused study and group-based learning activities. The modular wooden tables and ergonomic chairs were carefully selected for comfort and space efficiency: they can be easily moved, folded, or stacked to create open space for collaborative sessions or physical activities. This flexible setup aligns with Universal Design for Learning principles by allowing for quick adaptation to different learning formats. Each workstation is equipped with a floor or desk lamp featuring adjustable brightness and warmth, allowing students to control their immediate environment according to task, mood, or sensory preference. This enhances comfort during screen-based work and aligns with the principles of self-regulated learning and inclusive design.

The space is also used for informal interaction and interdisciplinary activities such as home economics. Biophilic design elements – including natural wood textures, adjustable lighting, and abundant greenery – create a calm and engaging atmosphere that supports cognitive focus, emotional well-being, and a sense of belonging. Large windows provide generous natural daylight, minimising reliance on artificial lighting and supporting circadian rhythm, mood regulation, and visual comfort. This aligns with the principles of biophilic and inclusive design, promoting attention restoration and reducing cognitive fatigue.

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Figure 2. Photo 3 – Emotional Support & Movement Zone

This soft-seating zone includes beanbags, patterned floor cushions, and a hanging chair to support learners who benefit from flexible seating or sensory variation. It serves as a retreat space for emotional self-regulation, individual reading, or quiet study, supported by a nearby table and lamp. The setup also supports group storytelling, hybrid presentations, and movement-based activities such as Just Dance sessions via the projector, providing both cognitive breaks and physical engagement – key for emotional well-being and digital fatigue prevention. The use of textured carpeting, natural materials, and plant elements strengthens the biophilic and inclusive nature of the space.

Figure 3. Photo 4 Multi-Use Relaxation, Dining, Study, and Game Zone

Located in a separate room from the main study area, this more relaxed zone offers learners flexibility to choose between light study, creative play, or informal social interaction. Students may use individual tables for personalised tasks or decompress by playing collaborative games such as the air hockey table seen near the window.

The open shelving contains books, tactile objects, and board games that promote exploratory learning and social-emotional development – particularly beneficial for neurodiverse learners. Biophilic elements like live plants and soft blue-green wall tones enhance comfort and well-being, while natural daylight maintains a calm, open feel.

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Figure 4. Photo 5 – Emotional Retreat and Individual Study Nook (Future Living Wall Area)

This quiet corner features hanging chairs designed to serve as semi-private spaces for emotional decompression, self-regulation, or focused study. The gentle swaying motion and cocooned form of the chairs simulate natural environments and offer students an emotionally safe space – particularly valuable for learners who benefit from reduced sensory stimulation or time alone.

Behind the chairs, the wall will host the student-created "living wall", to be assembled collaboratively during the piloting phase. This activity will foster a sense of community and responsibility, with each student contributing a personal plant. The setting exemplifies the integration of biophilic and emotionally responsive design principles, blending relaxation and learning in one adaptable zone.

Figure 5. Photo 6 – Entrance and Tutor Welcome Area

The entrance area includes a tutor coordination space and a natural-light-filled arrival zone. A simple round table and soft-edged chairs provide a welcoming point for informal check-ins, daily planning, or one-on-one tutor-student conversations. The use of circular forms reflects biophilic design principles, which emphasise natural shapes to promote calmness and reduce cognitive tension. Potted greenery near the window reinforces the connection to nature from the first point of entry.

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