Co-funded by
the European Union

Green Roofs and Vertical Gardens – Enhancing Urban Biodiversity

BIOS4YOU
AR 2.0

BIO-INSPIRED STEM TOPICS FOR ENGAGING YOUNG GENERATIONS
THANKS TO THE USE OF AUGMENTED REALITY

Project Number: 2023-1-DE03-KA220-SCH-000126516

KIT Karlsruher Institut für Technologie · ktu kaunas university of technology · Università degli Studi di Palermo · CEIPES · Eduact

Co-funded by
the European Union

Table of Contents

Project Number: 2023-1-DE03-KA220-SCH-000126516

Co-funded by
the European Union

Image 1. Green Roofs and Vertical Gardens – Enhancing Urban Biodiversity

General topic of the learning path	Urban Ecosystem Integration
Specific name of the learning unit	Green Roofs and Vertical Gardens – Enhancing Urban Biodiversity
Age of the target users	14-18 years
Requirements for the learner	1. Basic understanding of environmental science concepts (e.g.,water recycling). Basic literacy and numeracy skills. Basic ICT skills. 2. Access to a computer or tablet with internet connectivity. 3. Willingness to engage with digital tools (AR apps, Delightx). 4. No prior coding or AR development experience required
Description of the learning unit	This unit explores how green roofs and vertical gardens contribute to urban biodiversity and sustainability. Students will learn about their design principles, environmental benefits, and socio-economic impacts. It is divided into three sections: "Explore" introduces foundational concepts of climate change, ecosystems, and restoration. "Execute" delves into bio-inspiration, showcasing how natural processes inspire solutions and how Augmented Reality (AR) can visualize these processes and impacts, supported by real-world examples and

Project Number: 2023-1-DE03-KA220-SCH-000126516

	practical activities. "Enhance" justifies the pedagogical benefits of AR, offering examples of useful AR applications and practical integration strategies. The unit culminates in a hands-on exercise where students use a gamified AR experience in Delightex to strengthen their understanding and engagement with the topic.
Subject: Parties involved	Environmental Science, Biology, Geography, Design & Technology, Urban Planning, ICT/Computer Science.
Keywords	Green Roofs, Vertical Gardens, Urban Biodiversity, Urban Ecosystems, Sustainability, Bio-inspiration, Biomimicry, Augmented Reality (AR), Urban Greening, Climate Change Mitigation, Stormwater Management, Air Quality, Habitat Creation, Sustainable Architecture, Smart Cities.
Key qualifications, skills and knowledge that can be acquired	Qualifications (Mindset/Attitude): ● Environmental awareness. ● Proactive and innovative thinking towards environmental challenges. ● Appreciation for nature's role in sustainable solutions. ● Motivation to participate in climate action. Skills: ● **Critical Thinking:** Analyzing environmental problems and proposing solutions. ● **Problem-Solving:** Applying bio-inspired concepts to environmental challenges. ● **Digital Literacy:** Navigating and utilizing AR applications. ● **Scientific Inquiry:** Interpreting data and observing natural processes (virtual or real). ● **Communication:** Explaining complex environmental concepts and presenting restoration ideas. Knowledge:

Project Number: 2023-1-DE03-KA220-SCH-000126516

	• Understanding different types of green roofs and vertical gardens. • Familiarizing with various biodiversity methods. • Recognising bio-inspired solutions derived from nature. • Understanding the potential and applications of Augmented Reality in environmental education.
Resources and didactic aids used	Resources: • Textbooks/Scientific articles • Case studies • Internet resources • Free AR platforms (Delightex) • AR-compatible devices (smartphones/tablets)
Assessment criteria and evaluation	• **Participation:** Engagement in discussions and activities throughout the unit. • **Activity Completion:** Execution of practical AR exercise • **Concept Map/Mind Map:** Creation of a visual representation linking Green solutions, Urban Biodiversity, and bio-inspired solutions.

Project Number: 2023-1-DE03-KA220-SCH-000126516

Co-funded by
the European Union

Introduction

As our cities continue to grow, so does the need to create sustainable, resilient, and vibrant urban environments. This unit will explore how incorporating natural elements into our built spaces can foster biodiversity, mitigate climate change impacts, and improve the well-being of urban dwellers. We will delve into the concepts, benefits, and practical applications of green roofs and vertical gardens, and discover how cutting-edge technologies like Augmented Reality (AR) can deepen our understanding and engagement with these vital urban greening solutions. Get ready to explore, execute, and enhance your knowledge of how nature can thrive in the heart of our cities!

1. Explore – Foundations of Green Roofs and Vertical Gardens

Urbanization, while offering numerous opportunities, also presents significant environmental challenges, including habitat loss, increased urban heat island effect, and reduced air quality. Green roofs and vertical gardens emerge as innovative nature-based solutions to these issues, integrating vegetation directly into the urban fabric.

1.1 What are Green Roofs and Vertical Gardens?

A **Green Roof**, also known as a living roof, is a roof of a building that is partially or completely covered with vegetation and a growing medium, planted over a waterproofing membrane. They can be categorized into two main types:

- **Extensive Green Roofs:** Characterized by a shallow growing medium (typically 2-6 inches deep) and low-maintenance, drought-tolerant vegetation such as sedums, grasses, and wildflowers. They are lightweight and require minimal irrigation once established (Snodgrass & McIntyre, 2010).
- **Intensive Green Roofs:** Feature a deeper growing medium (6 inches to several feet deep) and can support a wider variety of plants, including shrubs and even small trees. They require more structural support and maintenance, often resembling traditional ground-level gardens (Mentens et al., 2006).

A **Vertical Garden** also known as living walls or green walls, vertical gardens are systems where plants are grown vertically on a specially designed structure attached to a wall, either freestanding or as part of a building. They can be:

- **Panel Systems:** Plants are grown in individual modules or panels that are then attached to a support structure.

Project Number: 2023-1-DE03-KA220-SCH-000126516

- **Trellis Systems:** Climbing plants are grown up a support structure, such as a trellis or cables, rooted in a ground-level planter.
- **Hydroponic Systems:** Plants are grown without soil, using nutrient-rich water solutions.

1.2 What are the benefits of Green Roofs and Vertical Gardens?

These urban greening solutions offer a multitude of ecological, economic, and social benefits:

- **Biodiversity Enhancement:** Provide new habitats for birds, insects (especially pollinators), and other small urban wildlife, counteracting habitat fragmentation.
- **Stormwater Management:** Absorb and filter rainwater, reducing runoff and the burden on urban drainage systems, thereby mitigating flood risks.
- **Urban Heat Island Effect Mitigation:** Reduce ambient air temperatures through evapotranspiration and by shading building surfaces, leading to cooler cities.
- **Improved Air Quality:** Plants filter air pollutants such as particulate matter, nitrogen oxides, and volatile organic compounds.
- **Energy Efficiency:** Insulate buildings, reducing heating needs in winter and cooling needs in summer, leading to energy savings.
- **Noise Reduction:** Vegetation can absorb and deflect sound, contributing to quieter urban environments.
- **Aesthetic and Psychological Benefits:** Enhance the visual appeal of urban spaces, promoting a sense of well-being, reducing stress, and fostering connection with nature.

2. Execute – The role of Augmented Reality in Enhancing Urban Biodiversity

In recent years, the intersection of technology and ecology has opened up innovative avenues for addressing pressing environmental challenges. One such promising area lies in the application of Augmented Reality (AR) to enhance and manage urban biodiversity. By overlaying digital information onto the physical world, AR offers a powerful tool for visualizing, planning, and maintaining green infrastructure like green roofs and vertical gardens.

2.1 Specific features and types of AR Tools

An AR application for this purpose would be more than just a visualization tool; it would be a dynamic platform for discovery, design, and problem-solving. Key features and tools would include:

Project Number: 2023-1-DE03-KA220-SCH-000126516

- **3D Model Visualization:** Project 3D models of proposed urban developments onto a real-world map (e.g., their school grounds or local park) and then overlay simulations of how these developments might impact local wildlife habitats, water flow, or light pollution.
- **Data Visualization Overlays:** Overlay virtual representations of biomimetic architectural elements (e.g., a building façade inspired by a desert beetle's water collection) onto existing structures, allowing students to "see" how these designs could function in real time.
- **Identification and Information:** Use AR to "discover" virtual wildlife species in designated urban areas, learning about their habitats, behaviors, and how urban design decisions affect them.

2.2 Real studies and practical exercises

Several real studies and educational initiatives have demonstrated the power of AR in environmental education and hands-on learning, particularly when inspired by bio-inspiration.

3. Enhance – Augmented Reality for deeper learning and engagement

Augmented Reality (AR) tools and applications are a powerful medium for environmental and urban education because they transform abstract concepts into tangible, interactive, and memorable experiences. For a topic as complex as "Enhancing Urban Biodiversity" where the goal is to integrate natural systems into the built environment, AR provides a unique ability to bridge the gap between theory and practice. It does this by:

- **Deepening Understanding of Complex Concepts:**
  - **Visualization of the Unseen:** AR can make invisible ecological processes happening in green roofs and vertical gardens visible to students. For example, an AR overlay could show how rainwater filters through layers of a green roof, how roots stabilize soil in a vertical garden, or how plants capture fine dust and improve air quality. Instead of static textbook diagrams, students see these processes unfold in real-time on the living systems in front of them.
- **Making Complex Concepts Accessible:**
  - **Bridging Theory and Reality:** Ideas such as urban heat island mitigation, stormwater management, or biodiversity support are often difficult to grasp. AR can project overlays onto a real green roof, showing temperature differences compared to traditional roofs, the movement of water before and after absorption, or pollinators interacting with rooftop

Project Number: 2023-1-DE03-KA220-SCH-000126516

flowers. Students can “step into” these simulations and directly connect theory with the functioning of the green infrastructure they’re observing.

- **Increasing Engagement and Motivation:**
  - **Immersion:** By interacting with digital layers that explain plant physiology, water cycles, or energy savings, students are drawn into immersive experiences where learning feels tangible, memorable, and playful.
  - **Gamification:** Integrating game-like elements (challenges, points, progress tracking) within AR experiences boosts motivation and encourages persistence.

3.1 Examples of Useful AR Apps and Tools

Various AR tools can significantly enhance the learning experience for ecosystem restoration by providing immersive and interactive ways to explore complex environmental concepts. Here is an example:

Delightex (CoSpaces Edu):

Delightex allows users to create interactive 3D virtual worlds and then experience them in augmented reality or virtual reality. It features a drag-and-drop interface and a visual block-based coding language (CoBlocks), making it highly accessible for students and teachers with no prior coding experience. It offers a free version with core functionalities. Students can design and build their own virtual ecosystems, simulate environmental changes, and visualize restoration efforts. Its creative freedom empowers students to become content creators, not just consumers.

3.2 Practical Suggestions for Integration into the Learning Experience

Gamified learning environments or interactive 3D virtual worlds can challenge students to explore green infrastructure like green roofs and vertical gardens in a city to mitigate the effects of climate change like flooding and heatwaves. This makes learning about urban design both fun and informative.

Exercise: “Green up the building” AR App

This AR exercise helps students explore how green roofs and vertical gardens can transform buildings and improve urban environments. The “Green up the building” exercise is designed as a game to make learning interactive and fun, while reinforcing key sustainability concepts. Students will understand how vegetation on buildings helps. Students will be challenged to “green” a virtual building they see through AR. Their mission is to add green roofs and vertical gardens strategically in order to

Project Number: 2023-1-DE03-KA220-SCH-000126516

maximize environmental benefits. As they play, they will see real-time overlays showing how plants reduce heat.

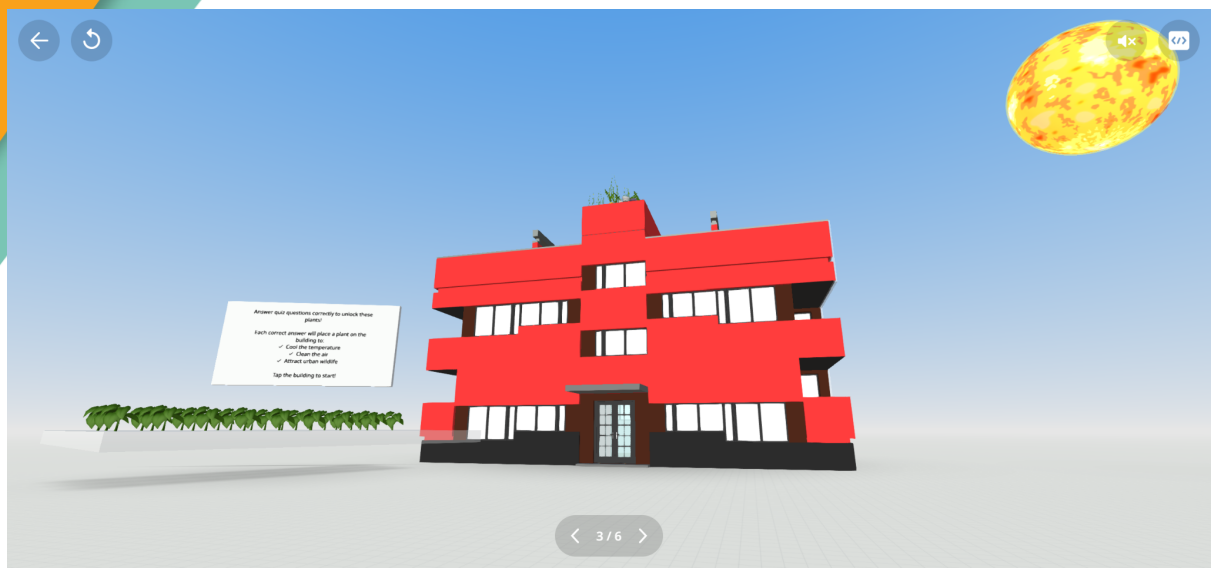

Image 2. Green Roofs and Vertical Gardens - Enhancing Urban Biodiversity

By making learning more immersive, interactive, and directly relevant to the students' immediate environment, AR technology significantly strengthens their connection to urban ecosystems and promotes more effective knowledge building for future sustainable urban development.

Conclusion

This learning unit has journeyed through the exciting world of urban ecosystem integration, focusing on the remarkable potential of green roofs and vertical gardens. We've explored their fundamental concepts, understood their myriad benefits for urban biodiversity and environmental resilience, and discovered how the principles of bio-inspiration guide their design. Crucially, we've seen how Augmented Reality (AR) can revolutionize the learning process, transforming abstract ideas into tangible, interactive experiences. From visualizing complex systems to virtually designing our own sustainable urban spaces, AR empowers us to become active participants in building greener, healthier cities. As you continue your learning journey, remember that every green roof and vertical garden is a testament to our ability to integrate nature into the urban fabric, creating thriving ecosystems where both humans and biodiversity can flourish. Let's continue to be inspired by nature and use innovative tools to cultivate a more sustainable future.

Project Number: 2023-1-DE03-KA220-SCH-000126516

Phase	Description
Explore	- Research and Discovery: Explore the role of **green roofs and vertical gardens** in enhancing urban biodiversity. Explain how they mitigate urban heat, support pollinators, and improve air quality.
	- Content Development: Provide accessible background on ecological functions (stormwater retention, insulation, habitat creation) using visuals, short readings, or mini-lectures.
	- Needs Analysis: Identify students' baseline knowledge of urban ecology and sustainability to tailor activities and ensure all learners can build on a solid foundation.
Execute	- Curriculum Implementation: Connect the concept of bio-inspiration to architecture, using AR showing how plants' natural abilities inspire sustainable building design.
	- Interactive Exercises: Analyze real case studies. Walk through spaces with AR overlays (e.g., green roofs, wildlife passages).
	- Feedback Collection: Share AR designs, reflect on outcomes, and get feedback from peers/teachers.
Enhance	- AR Integration: Use the AR app "Green up the building" to visualize green roofs and vertical gardens.
	- Interactive Learning: interact with a virtual building through AR, adding green roofs and vertical gardens in strategic locations. Real-time overlays show how their choices impact temperature reduction, water absorption, and air quality improvement.
	Gamified Content: -**Quests and Levels:** Answer correctly embedded quiz questions and progress through levels by strategically adding green roofs and vertical gardens to the virtual building. -**Rewards for Exploration:** Unlock new plant species or advanced AR visualizations as students answer quiz questions.
	AR-Based Assessments: Replace traditional tests with AR-based evaluations, such as students exploring their AR urban ecosystem models or completing biodiversity "quests" in real environments.

References

Akbari, H. (2002). Shades of green: The effects of urban trees and shrubs on energy use and air quality. *Energy and Buildings, 33*(2), 95-104.

Azuma, R. T., Baillot, Y., Behringer, R., Feiner, S., Julier, S., & MacIntyre, B. (2001). Recent advances in augmented reality. IEEE Computer Graphics and Applications, 21(6), 34-47.

Gedge, D., & Kadas, G. (2007). Green roofs and biodiversity. *Journal of Green Building, 2*(1), Mentens, J., Raes, D., & Hermy, M. (2006). Green roofs as a tool for

Project Number: 2023-1-DE03-KA220-SCH-000126516

"Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor EACEA can be held responsible for them."

solving the rainwater runoff problem in the urbanized 21st century?. Landscape and urban planning, 77(3), 217-226.12-25.

Wang, Y., & Li, G. (2020). Applications of augmented reality in science education: A systematic review. Journal of Educational Technology & Society, 23(3), 108–122.

Wu, H. K., Lee, S. W. Y., Chang, H. Y., & Liang, J. C. (2013). Current status, opportunities and challenges of augmented reality in education. Computers & Education, 62, 41-49.

Snodgrass, E. C., & McIntyre, L. (2010). The green roof manual: a professional guide to design, installation, and maintenance. (No Title).

Project Number: 2023-1-DE03-KA220-SCH-000126516

Co-funded by
the European Union

BIOS4YOU AR 2.0

BIO-INSPIRED STEM TOPICS FOR ENGAGING YOUNG GENERATIONS
THANKS TO THE USE OF AUGMENTED REALITY

Project Number: 2023-1-DE03-KA220-SCH-000126516