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Innovative Water Recycling and Conservation Techniques in Urban Planning

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

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Image 1. Innovative Water Recycling and Conservation Techniques in Urban Planning

General topic of the learning path	Climate Change and Its Impact on Biodiversity
Specific name of the learning unit	Innovative Water Recycling and Conservation Techniques in Urban Planning
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 learning unit provides a comprehensive introduction in innovative water recycling and conservation techniques in urban planning. 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 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, Digital Literacy/Computer Science, Art & Design, Social Studies (community action), Mathematics (data analysis in restoration), Language Arts (research, communication)
Keywords	Climate Change, Ecosystem Restoration, Nature-Based Solutions, Carbon Sequestration, Biodiversity, Ecosystem Services, Bio-inspiration, Biomimicry, Environmental Education, Sustainability, Reforestation, Wetland Restoration, Soil Regeneration, Digital Literacy, Augmented Reality (AR), Gamification.
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).

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	• **Communication:** Explaining complex environmental concepts and presenting restoration ideas. Knowledge: • Understanding different types of water recycling and harvesting. • Understanding of the impacts of rainwater harvesting. • Familiarizing with various recycling techniques in urban planning. • Recognising the way rainwater harvesting combats urban planning impact. • 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 climate change, ecosystems, restoration methods, and bio-inspired solutions.

Introduction

Water is a fundamental resource, essential for life, ecosystems, and human development. However, rapid urbanization, climate change, and increasing population densities are placing unprecedented stress on global water supplies. Traditional water management approaches, often relying on centralized systems and linear consumption, are proving unsustainable. This learning unit will delve into innovative solutions for sustainable water management in urban environments, focusing

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specifically on advanced water recycling and conservation techniques. Through an exploration of core concepts, practical applications inspired by nature, and the transformative potential of Augmented Reality (AR) tools, learners will gain a comprehensive understanding of how cities can achieve water resilience. By the end of this unit, students will be equipped with knowledge and practical insights to advocate for and contribute to more sustainable urban water futures.

1. Explore – Foundations of Sustainable Water Management

Sustainable water management refers to the process of managing water resources to meet the needs of the present without compromising the ability of future generations to meet their own needs. It involves balancing human water demands with the health of aquatic ecosystems, ensuring equitable access, and promoting efficient use. Key principles include:

- **Water conservation:** Reducing overall water consumption.
- **Water efficiency:** Using less water to achieve the same task.
- **Water reuse and recycling:** Treating wastewater for beneficial purposes.
- **Source protection:** Safeguarding natural water bodies and aquifers.
- **Integrated water resources management (IWRM):** A holistic approach that coordinates the development and management of water, land, and related resources.

1.2 What are Innovative Water Recycling Techniques?

Water recycling involves treating wastewater from various sources and reusing it for beneficial purposes. This significantly reduces the demand on fresh water supplies.

Greywater Recycling:

Greywater is domestic wastewater generated from non-toilet plumbing fixtures such as showers, bathtubs, washing machines, and sinks. It typically has lower levels of contaminants than blackwater. After minimal treatment (e.g., filtration, disinfection), greywater can be safely reused for irrigation (gardens, landscaping), toilet flushing, and laundry in homes and buildings. Greywater usage reduces potable water consumption, lowers wastewater discharge, recharges groundwater, and saves energy.

Blackwater Treatment and Reuse:

Blackwater is wastewater from toilets and kitchen sinks, containing higher concentrations of pathogens and organic matter. Requires more advanced treatment processes (e.g., biological treatment, membrane filtration, UV disinfection) to meet stringent quality standards for non-potable uses like urban irrigation, industrial processes, and sometimes even groundwater recharge or indirect potable reuse. Maximizes water resource utilization, reduces reliance on freshwater sources, and minimizes environmental pollution.

Rainwater Harvesting:

The collection and storage of rainwater from rooftops or other surfaces. Harvested rainwater can be used for non-potable purposes such as garden irrigation, toilet flushing, car washing, and sometimes even potable uses after advanced treatment. This technique reduces stormwater runoff (which can cause flooding and pollution), supplements municipal water supply, and lowers water bills.

1.3 What are Water Conservation Techniques in Urban Planning?

Urban planning plays a critical role in integrating water conservation strategies into the built environment.

Permeable Pavements:

Porous surfaces (e.g., permeable concrete, asphalt, pavers) that allow stormwater to filter through, rather than running off, into the ground below. Used in parking lots, sidewalks, and low-traffic areas. Reduces stormwater runoff, recharges groundwater, filters pollutants, and mitigates urban heat island effect.

Green Roofs and Walls:

Rooftops or vertical surfaces covered with vegetation planted over a waterproofing membrane. Integrated into commercial buildings, residential complexes, and public infrastructure. Absorb and filter rainwater, reduce stormwater runoff, insulate buildings (lowering energy consumption), improve air quality, and provide habitat for biodiversity.

Efficient Irrigation Systems:

Technologies and practices that minimize water waste in landscape irrigation. Drip irrigation, smart controllers that adjust watering schedules based on weather and soil moisture, and selection of drought-tolerant plants. Significantly reduces outdoor water consumption, conserves freshwater, and promotes healthier landscapes.

By understanding these core concepts and techniques, learners will be well-prepared to explore the practical applications and the role of emerging technologies in fostering water-resilient cities.

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2. Execute – The Role of Augmented Reality Innovative Water Recycling and Conservation Techniques in Urban Planning

Augmented Reality (AR) is emerging as a powerful tool in advancing innovative water recycling and conservation strategies within urban planning. By enabling interactive visualization, simulation, and real-time data integration, AR enhances how planners, engineers, and communities understand the flow, reuse, and efficiency of water systems. From virtual demonstrations of greywater recycling and rainwater harvesting to simulations of smart irrigation and stormwater management, AR not only accelerates the adoption of sustainable practices but also fosters greater awareness of water's environmental and social value. This immersive approach supports more informed decision-making, paving the way for cities to design resilient, resource-efficient, and water-sensitive futures.

2.2 How an AR Application Supports Learning Objectives?

An Augmented Reality (AR) application can profoundly enhance the learning experience for sustainable water management by making abstract concepts tangible and providing immersive, interactive engagement. The main objective of this training unit is to equip learners with knowledge and practical insights into innovative water recycling and conservation techniques. An AR app can support this by:

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 could include:

- **3D Model Visualization:** Allowing students to interact with 3D models of urban water infrastructure, green roofs, or permeable pavements, seeing how components fit and function together. Making the movement of water (e.g., groundwater flow, greywater recycling paths within a building) visible and understandable.
- **Interactive "What If" Scenarios:** Users could manipulate variables (e.g., rainfall intensity, population density) and see the AR-projected impact on water runoff or availability.
- **Simulations:** Placing students virtually within different urban settings to observe the impact of various water management strategies (e.g., seeing how a green roof absorbs rainfall vs. a traditional roof).

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2.2 Real studies and practical exercises

Meaningful integration of AR in hands-on learning is already happening globally, particularly in fields like environmental and urban education. These examples demonstrate how AR can move students beyond passive observation and into active, creative problem-solving inspired by nature. Integrating real-world examples and hands-on activities, augmented by AR, solidifies learning.

This case study explored the effectiveness of Augmented Reality (AR) as a tool to engage youth in urban planning processes, specifically focusing on a project in Oslo, Norway, where young participants were tasked with planning the placement of new trees.

The study involved fieldwork conducted over five weeks (between 2020 and 2021) with five different groups of youth from various districts of Oslo. These participants utilized AR technology to visualize and design urban development models by overlaying them onto real-world spaces. The researchers documented the youth's interactions through films, images, drawings, interviews, and screen recordings. AR proved to be a highly intuitive tool for the youth in their design and planning tasks. AR aided the users' ability to generate their own planning proposals on-site and at scale, significantly increasing their motivation and willingness to participate in planning processes. The study concluded that AR can significantly improve the quality of participation processes in urban planning by presenting different planning concepts more realistically and increasing engagement, particularly among young people. It highlighted both the opportunities and barriers for implementing AR in participatory urban planning, emphasizing the need for a more coordinated and holistic approach to both AR technology development and planning policy for its further integration into sustainable urban transitions (Reaver, 2023).

3. Enhance – AR for Deeper Learning and Engagement

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

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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.

Exercise: “Rainwater Harvesting” AR App

“Rainwater Harvesting” AR App lets students explore a virtual house and learn how rainwater harvesting works in everyday spaces like the kitchen, bathroom, rooftop, and garden. As you move through each scene, you’ll see animations of how rain is collected, stored, and reused, along with quick facts about saving water. At the end of each area, a short quiz tests your knowledge. By the end, you’ll understand how simple actions at home can help conserve millions of liters of water and reduce our environmental footprint.

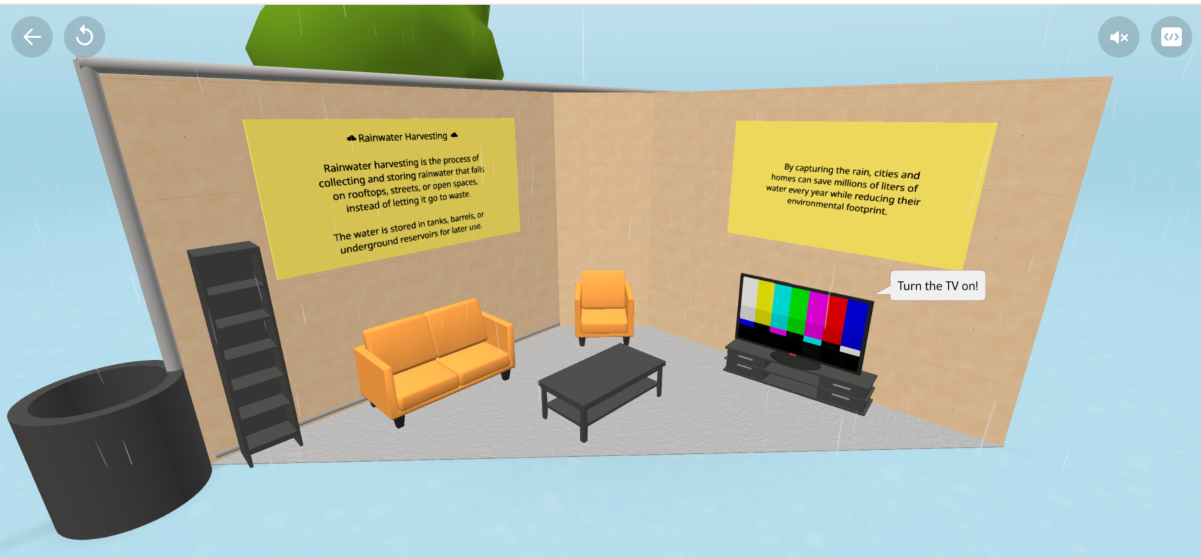

Image 2. “Rainwater Harvesting" AR App

By strategically integrating AR, educators can create dynamic, interactive, and highly effective learning environments that not only convey complex information about sustainable water management but also inspire students to become active participants and innovators in solving real-world environmental challenges.

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Phase	Description
Explore	- Research and Discovery: Introduce students to rainwater harvesting concepts, including collection, storage, and reuse in homes and urban environments. Explain environmental benefits like water savings and reduced runoff.
	- Content Development: Develop concise, engaging content for each area of the house (rooftop, kitchen, bathroom, garden), including animations, key facts, and real-world examples.
	- Needs Analysis: Assess students' baseline understanding of water conservation, plumbing, and sustainability to tailor AR content and quiz difficulty.
Execute	- Curriculum Implementation: Connect the concepts of water conservation, rainwater harvesting, and sustainable urban planning to practical actions students can observe in everyday environments. Students learn how rainwater can be collected, stored, and reused to reduce water consumption and environmental impact.
	- Interactive Exercises: Using the AR app, students explore a virtual house, including the rooftop, kitchen, bathroom, and garden. Animations demonstrate rainwater flow, collection systems, and storage methods. At the end of each area, students complete a short quiz to test their understanding of water recycling principles.
	- Feedback Collection: Students receive immediate feedback from the AR system on correct or incorrect choices, and teachers facilitate discussion on strategies to optimize water use in urban spaces.
Enhance	- AR Integration: Students explore an AR house, observing water collection, storage, and reuse systems in each room. Short quizzes after each scene reinforce learning.
	- Interactive Learning: Students earn points for correctly answering quizzes and making effective water-saving decisions. Badges reward mastery of key concepts like rainwater capture, storage efficiency, and reuse techniques.
	Gamified Content: - **Rewards for Exploration**: Students earn positive feedback for correct quiz answers and effective water-saving decisions.
	AR-Based Assessments: Replace traditional tests with interactive evaluations, such as completing AR scenarios, demonstrating understanding of water recycling principles, and proposing strategies for urban water conservation.

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