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The Smart Recycling Lab

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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General information

This document describes the Augmented Reality (AR) exercise titled The Smart Recycling Lab, designed for students aged 14–19 within the framework of the BioS4You project.

The aim of this exercise is to help students understand the principles of waste transformation and circular economy through a hands-on, interactive learning experience. Using Assemblr EDU, students will access an AR environment where various types of waste appear on a real-world surface (such as a desk or classroom table). By selecting each waste object, students navigate through decision scenarios where they choose between different disposal methods (recycling, reusing, or improper disposal) and discover the environmental consequences of each choice.

This document follows the standard BioS4You AR Exercise template and is organized into the following sections:

General Information: title, authors, target group, duration, keywords, and topics

Pedagogical Specifications: learning objectives, methodology, integration with curriculum

Technical Specifications: hardware, software, AR experience design

The exercise has been developed using the 3E approach (Explore – Execute – Enhance), encouraging students to engage, interact, and reflect throughout the learning process.

Thanks to AR, students are immersed in an enriched environment where text, images, and 3D objects appear in the real world. This combination of digital media and physical space helps to enhance attention, reinforce concepts, and support a deeper understanding of environmental sustainability.

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Name of the exercise:	**The Smart Recycling Lab** *From waste to clean resources: a circular bio-cycle for the creation of an eco-habitat* The title highlights both the educational goal and the technological setting of the exercise. "Smart" refers to the interactive, decision-based structure where students make real-time choices and see the outcomes. "Recycling Lab" emphasizes the experimental dimension, simulating a laboratory in which learners test waste management options. The subtitle "From waste to clean resources" reflects the transformation path explored in the activity, from discarded materials to sustainable solutions, culminating in the creation of an eco-habitat. This naming structure makes it accessible to an international audience of 14-19 year old students.
Description of the exercises:	The Smart Recycling Lab is designed for schoolchildren aged 14-19 to explore the principles of circular economy through Augmented Reality. The main objective is to make students aware of how waste can be transformed into valuable resources and how individual choices affect environmental sustainability. The exercise uses AR to place four types of waste objects (plastic bottle, aluminum can, paper, apple) on the real classroom desk. Students interact with each item by selecting it and then choosing among three disposal options: recycling, reusing, or improper disposal. Each choice leads to a result scene with visual representations and short explanatory text that highlights the environmental consequences. Before engaging with the AR waste objects, students access preparatory educational content through three integrated YouTube videos positioned in the initial AR scene. "Circular Economy Explained" provides foundational understanding of circular economy principles, "What Happens to Recycling" demonstrates real-world recycling processes, and "The 3 R's: Reduce, Reuse, Recycle" introduces waste hierarchy concepts. This preliminary phase ensures students possess theoretical background necessary for meaningful decision-making during the interactive AR experience. AR is used here because it allows students to see and manipulate abstract processes in a concrete way: instead of reading about recycling, they navigate through decision scenarios and discover the outcomes of different waste

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management choices. This visual and interactive approach improves engagement, supports critical thinking, and makes the concept of circular economy more accessible.

The learning experience concludes with a comprehensive assessment consisting of five multiple-choice questions that evaluate student understanding of circular economy principles, bioenergy concepts, and environmental impact evaluation. Rather than testing mechanical recall of AR interface elements, the assessment requires students to connect theoretical concepts from the preparatory videos with practical applications demonstrated in the AR scenarios, encouraging critical analysis of waste management strategies and sustainable development approaches aligned with contemporary environmental science education.

The exercise opens multiple design perspectives: how to recycle materials efficiently, how to reuse everyday objects creatively, and how to understand the environmental impact of waste disposal choices. Each decision path reinforces the connection between individual choices and environmental sustainability.

Participants:

The exercise is suitable for both individual students and small groups of 3-5 members. Working in groups is recommended to stimulate discussion, compare different disposal choices, and agree on the most sustainable options. Each group can use a single device to interact with the AR scene, which makes the activity practical even in classrooms with limited equipment.

When carried out individually, the exercise allows each student to explore the AR environment at their own pace and reflect on personal decision-making. In both formats, the activity encourages critical thinking and responsibility regarding waste management.

Participants' age range:

- Minimum age: 14 years
- Maximum age: 19 years

To take part in the activity, students should have a basic understanding of environmental science, particularly waste categories (organic, plastic, paper, aluminum) and the general idea of recycling and composting. No advanced digital skills are required, as Assemblr EDU is intuitive and guided by simple interactions on a smartphone or tablet.

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STEM subject and specific topic:	STEM Subject: Environmental Science, Biology, Technology Specific Topic: Circular economy, waste management, and sustainable ecosystems Main challenge of the topic: Students often struggle to recognize the differences between disposal methods (recycling, reuse, or improper disposal) and to understand the long-term environmental consequences of each. The abstract nature of waste transformation processes makes it difficult to connect everyday actions with global sustainability goals. In addition, the concept of circular economy is frequently presented in a theoretical way, which limits engagement and real comprehension. How AR helps simplify the concept: Through Assemblr EDU, students can interact with 3D models of waste items and directly choose a disposal method. Each choice leads to a result scenario with visual representations and short explanations, making the process clear and concrete. AR bridges the gap between abstract concepts and tangible results: students navigate through decision scenarios and see the outcomes of different waste management choices. This interactive feedback helps them understand cause-effect relationships and reinforces critical thinking about environmental impact.
Gamification process:	The gamification strategy follows the recommendations of the BIOS4YOU WP2 guidelines, focusing on challenge-based learning and simple, immediate feedback that can be realistically implemented with Assemblr EDU. • Challenge-based learning: students are presented with four different waste objects and must choose the most appropriate disposal method for each. Every decision leads to a specific result scenario that demonstrates the environmental consequences. • Immediate visual feedback: instead of points or badges (not supported by Assemblr EDU), feedback is represented through dedicated result scenes. Appropriate choices show positive outcomes like recycled materials or creative reuse applications, while poor choices display negative environmental impacts. • Role-playing element: learners act as "eco-engineers",

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making decisions that simulate real-world environmental responsibility. In group settings, they discuss and negotiate the best solutions together.

This approach combines interactivity, visual consequences, and narrative framing to keep students motivated, aligning with the gamification principles defined in the BIOS4YOU WP2 methodology and adapted to the technical possibilities of Assemblr EDU.

Written or graphic description of Augmented info:

The AR experience is developed in Assemblr EDU and includes the following elements:

- 3D models of waste items (plastic bottle, aluminum can, paper, apple) placed on a real surface such as a classroom desk.
- Decision-based navigation: by tapping on each object, students access dedicated decision scenes with three disposal options (recycling, reuse, improper disposal).
- Visual result scenarios: each choice leads to a specific scene showing the outcome - recycled materials, creative reuse applications, or environmental damage.
- Educational information: short descriptive texts in each result scene provide key data about environmental impact, decomposition times, and sustainability benefits.
- Navigation system: "Back to Lab" buttons allow students to return to the main scene and explore other waste types at their own pace.

These elements make abstract waste management processes visible and interactive, helping students to directly connect their disposal decisions with specific environmental consequences through concrete visual representations.

External (or extra) tools required

Devices: smartphones or tablets with the Assemblr EDU app installed (iOS or Android).

- AR markers: optional, printable markers can be provided to help students place the 3D models on the desk; otherwise, surface detection can be used.
- Printed worksheets: to allow students or groups to record their choices, reflect on the consequences, and prepare a short report.
- Internet connection: required to access the Assemblr EDU

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project.

- Educational video content: Three YouTube videos integrated in the initial AR scene provide preparatory content: "Circular Economy Explained," "What Happens to Recycling," and "The 3 R's: Reduce, Reuse, Recycle." Students access these through interactive buttons before engaging with waste objects.
- Assessment platform: Google Forms quiz with five multiple-choice questions evaluating understanding of circular economy principles, bioenergy concepts, and environmental impact evaluation. Quiz requires 10 minutes and provides automatic scoring for immediate feedback.

No other physical materials are strictly required. The exercise is designed to be implemented with standard classroom resources and mobile devices.

Links (video, images, text online and so on).

EDUCATIONAL VIDEOS

- Circular Economy Explained: https://www.youtube.com/watch?v=zCRKvDyyHml

- What Happens to Recycling After the Bin: https://www.youtube.com/watch?v=6RlxySFrkIM

- The 3 R's: Reduce, Reuse, Recycle: https://www.youtube.com/watch?v=OasbYWF4_S8

ASSESSMENT QUIZ

- Smart Recycling Lab Assessment: https://docs.google.com/forms/d/e/1FAIpQLSemSn2slPVgsbD-oBEojdhcVQA-X8jb6hyTVeQR_f-dZWLfJg/viewform?usp=header

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Pedagogical specifications

Here we will collect information on how to use the exercise in the learning session and the results and benefits of using it, from a pedagogical perspective.

How can this augmented information be used to address a STEAM topic in a more interesting way for students?

The Smart Recycling Lab uses AR to make the abstract concept of circular economy more concrete and engaging. Instead of reading about recycling rules, students see four different waste objects on their classroom desk and interact with them directly. Each decision – recycling, reuse, or improper disposal – leads to a dedicated result scene with visual representations and explanations. This visual cause-effect connection allows students to approach environmental science in a practical way, while also touching on technology and design thinking in a context that feels playful and immersive.

Which pedagogical objectives are addressed through this scenario?

The scenario aims to help students understand the relationship between daily actions and sustainability. The objectives include distinguishing among different waste management methods, recognizing their environmental consequences, and justifying choices with simple scientific reasoning. Another objective is to promote collaboration, since the activity can be done in small groups, and to strengthen digital competence through purposeful use of AR technology. Overall, the exercise connects scientific knowledge with civic responsibility.

Which results are expected to be reached with its use?

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By completing the exercise, students are expected to demonstrate a clearer understanding of recycling, reuse, and proper disposal methods. They should be able to explain how different choices lead to specific environmental outcomes and transfer this reasoning to real-world waste management practices. The activity is also expected to improve engagement: students show greater interest and participation because the concepts are experienced directly rather than only explained.

Which benefits are expected to be reached with its use?

The main benefits are increased motivation and deeper comprehension. AR makes learning more interactive, which keeps students focused and curious. The exercise also fosters critical thinking by showing that every choice has visible consequences. Working in groups encourages communication and shared decision-making, while the visual representation of consequences provides a sense of understanding. These benefits go beyond factual learning, supporting personal responsibility and sustainable habits in everyday life.

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Technical specifications

In this part it is necessary to specify whether the exercise was designed to be implemented with AR technology. This part is fundamental for the translation process. Please include text, audio text and all the necessary materials.

AR INFORMATION

Technology	https://asblr.com/gWwlga The exercise is designed to be implemented entirely with Augmented Reality. It uses markerless AR, since Assemblr EDU allows the placement of 3D objects directly on a detected flat surface such as a classroom desk or the floor.
If it's needed a marker, description of the marker	 No specific marker is required. Students can simply scan a flat surface with their smartphone or tablet camera. As an alternative, a simple QR code can be provided to give direct access to the AR scene.

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Hardware and software needed:	• Hardware: smartphones or tablets with camera and internet connection. Gyroscope and accelerometer are required (standard in most modern devices). • Software: Assemblr EDU app (free, available on Android and iOS). A PC can be used by teachers for creating or editing the project, but it is not required for student use.
Type of Augmented data	The AR experience integrates different types of content: • 3D models (waste items, plants, eco-habitat elements) • Text overlays (short explanations, feedback messages) • Scene transitions (navigation between decision scenarios and result displays)
Written description of the AR data	When students open the exercise with Assemblr EDU, they will see four 3D waste objects (plastic bottle, aluminum can, paper, apple) placed on a real desk surface. By tapping on an object, students navigate to a dedicated decision scene with three button options for disposal methods: recycling, reuse, or improper disposal. Each choice leads to a separate result scene that displays the specific outcome through representative 3D objects and brief explanatory text with key information about decomposition times and environmental impact.
If Image	If the AR data are Images, the formats needed are .jpg, and .png (better size < 2Mb) (*)
If Text	Short explanatory messages (e.g. "Plastic recycled into a new bottle", "Organic waste becomes compost") are displayed as overlays inside Assemblr EDU. An additional overlay with text "QUIZ" provides access to the external assessment platform with the following content: **Smart Recycling Lab - Advanced Assessment Quiz** Question 1: The AR experience demonstrates circular economy principles. What fundamental difference distinguishes the circular economy from the linear "take-make-dispose" model? - Circular economy uses only natural materials

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- Circular economy completely eliminates industrial production

- Circular economy transforms waste into resources, keeping materials in use for as long as possible (TRUE)

- Circular economy is based exclusively on recycling

Question 2: In the AR experience, choosing "Improper Disposal" shows negative consequences. According to the lesson, what are the real implications of incorrect waste management?

- Only increased economic costs

- Loss of valuable materials, environmental impacts on air/water/soil, and risks to human health (TRUE)

- Decreased industrial efficiency

- Exclusively urban aesthetic problems

Question 3: The AR shows apple composting becoming a "farm". How does this process connect to the "bioenergy" concept discussed in the lesson?

- Composting creates methane gas that can be directly burned for heating

- Composting transforms organic waste into soil nutrients that support biomass growth, which can later produce bioenergy through anaerobic digestion (TRUE)

- Composting eliminates the need for any external energy sources

- Composting only works for creating fertilizers, not energy production

Question 4: The lesson mentions that only 9% of the global economy is currently circular. How does the AR experience help understand this challenge?

- By showing that recycling is always the best solution

- By demonstrating that there are multiple options for each material, but awareness is needed to choose the most sustainable option (TRUE)

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	- By proving that AR technology can solve environmental problems - By indicating that organic waste is the main problem Question 5: Imagine designing an "eco-city" as described in the lesson. Based on principles learned in the AR experience, what would be the MOST effective waste management strategy applying circular economy? - Build more recycling plants and increase waste collection frequency - Implement an integrated system with biogas plants for organics, repair centers for reuse, local factories using recycled materials, and citizen education apps (TRUE) - Focus only on reducing waste production through strict regulations - Replace all packaging with biodegradable materials and ban non-recyclable products **Quiz access link:** https://docs.google.com/forms/d/e/1FAIpQLSemSn2slPVgsbD-oBEojdhcVQA-X8jb6hyTVeQR_f-dZWLfJg/viewform?usp=header
If video	-
If audio	-
If 3D model	3D models are needed in formats compatible with Assemblr EDU. These include four waste items (plastic bottle, aluminum can, paper, apple), result objects for each disposal method (recycled materials, reuse applications, environmental damage representations), and interactive button images in PNG format.and SensoryNeuron models from Assemblr's library, complete human nervous system model, molecular spheres representing neurotransmitters, Thunder Particle effects representing electrical impulses, and PNG button images for navigation between scenes.

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