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STEM DIGITALIS

EDUCATOR GUIDE

- Ocean Batteries and Energy Farms -

PART OF THE INTELLECTUAL OUTPUT 3

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Table of contents

Chapter 1: Introduction

This document serves as an Educator's Guide for teacher educators, teachers, and academics in order to implement the Ocean Batteries and Energy Farms digital scenario.

It contains the rationale for teaching this scenario, the structure of the scenario and a description of each activity. Each activity is described in terms of a five-dimensional framework, providing information about the activity's timing, mode, approach, group synthesis and the kind of media used (for more details please see IO2).

	Icon used to indicate information about the way of conducting each activity in terms of the 5-dimensional framework.

The guide also includes hints for the instructors, indicating possible difficulties in implementing the scenario, and strategies to overcome them. These hints are indicated in a green frame, as shown in Figure 1.

Hint:

The use of shared documents supports the comparison of pre-service teachers' initial ideas expressed in Activity 1 with their final conclusions formulated in Activity 3 of Unit 1.

Fig.1 Example of a "Hint box"

Finally, suggestions of alternative ways to conduct each activity are provided, e.g. implementing the activity fully online. These alternatives are indicated in an orange frame, as shown in Figure 2.

Alternative:

Activity 3 can also be conducted in an on-line synchronous mode. In that case the educator should use a teleconference application that provides separate virtual rooms for pre-service teachers to firstly discuss with their peers their views and then present them to the whole group.

Fig. 2 Example of an "Alternative box"

Chapter 2: Why teach about Ocean Batteries and Energy Farms?

Human efforts to make use of renewable energy sources have a long history. Humans have used 'natural forces' such as fire, water, etc. for their survival and for improving the quality of their lives since ancient times (Delyannis & El-Nashar 2010). One of the abundant and promising renewable energy sources is ocean power, i.e. making use of the mechanical and/or thermal energy of ocean water quantities in order to harness energy. Specifically, according to the International Energy Agency (2017), ocean power can be exploited using several technologies, such as: a) tidal rise and fall (barrages), b) tidal/ocean currents, c) waves, d) temperature gradients, and e) salinity gradients. Among these five technologies, focus has been mostly given to tidal and wave power (a,b,c) (Melikoglu 2018).

The reason behind using ocean water as an energy source through the development of on-site energy harvesting 'farms', is that it is a sustainable, environmental-friendly and abundant energy source. On the contrary, energy farms that make use of fossil fuels pollute the environment and accelerate global warming (Lonngren & Bai 2008). Therefore, it becomes important to teach the young generations of students and teachers about renewable energy sources such as ocean energy farms in order to raise students' awareness to address climate change and global warming problems that threaten humanity.

However, the energy that comes from renewable energy sources is not stable, since it depends on weather conditions. That can cause multiple problems, from instability of energy supply which can cause blackouts to overproduction of energy which can lead to negative prices (Di Modugno 2021; Jonker, 2018). In order to address these problems, energy storage technologies are needed. One of these technologies is the ocean battery technology such as the one developed by the Ocean Grazer project (https://oceangrazer.com/). This kind of energy storage devices contains environmentally friendly materials and settings that aim to minimise the disruption of marine ecosystems, while trying to maximise their efficiency.

The ocean battery technology makes use of devices (flexible bladders, pumps and turbines) that move water from areas of lower pressure to areas of higher pressure and vice versa, and hence store or use energy, respectively, depending on human needs. Consequently, the main operation principles are based on science content that relates to school curricula, even for younger ages of students. These include hydrostatic pressure, pressure difference and fluid motion, forms of energy, transformation and conservation of energy, etc. Therefore, this topic is recommended for instruction in secondary and primary education contexts, since it relates to the science content of the school curricula and at the same time serves society-relevant goals.

Chapter 3: Structure of the digital scenario

The digital scenario consists of the following three main units:

- Unit 1: Real-world problem contextualization
- Unit 2: Engineering design of the ocean batteries and energy farms
- Unit 3: Reflection

In the first unit, pre-service teachers familiarise themselves with the gamification platform, formulate small groups and progressively explore the rationale of using renewable energy sources, ocean power and ocean batteries through the first 2 stages of the platform. In specific, the participants engage with prompts and texts while interacting with objects in a virtual space, keeping online notes, discussing with peers, and interacting with virtual assistants. Virtual assistants are presented in the form of augmented reality objects and dialogue trees with the participants in order to collect the information needed. At the end of each stage, they have to answer the questions posed by the AR assistants in order to access the password for the next level. The first two stages concern: a) getting to know elements regarding the historical evolution of renewable energy sources, b) the real-world problems that stress the need for renewable energy sources, c) the facts that support the need of energy storage technologies for renewable energy sources.

In the second unit, the participants experimentise with simulations of the ocean batteries (charging and discharging operations), as well as the design of Wave Energy Converters (WEC) and wind turbines. Particularly, they change variables and test the efficiency of the module through several inquiry circles in order to make inferences and draw conclusions.

In the third unit, pre-service teachers reflect with peers on a) the design of the ocean battery and energy farms module, b) socioscientific issues related to the scenario, c) interdisciplinary aspects of the scenario, d) engineering practices, based on what they have experienced in the digital scenario.

The recommended sequence of the activities in the three units is depicted in Figure 1. However, the educators can make a selection of the activities that they consider appropriate for their own audience and context.

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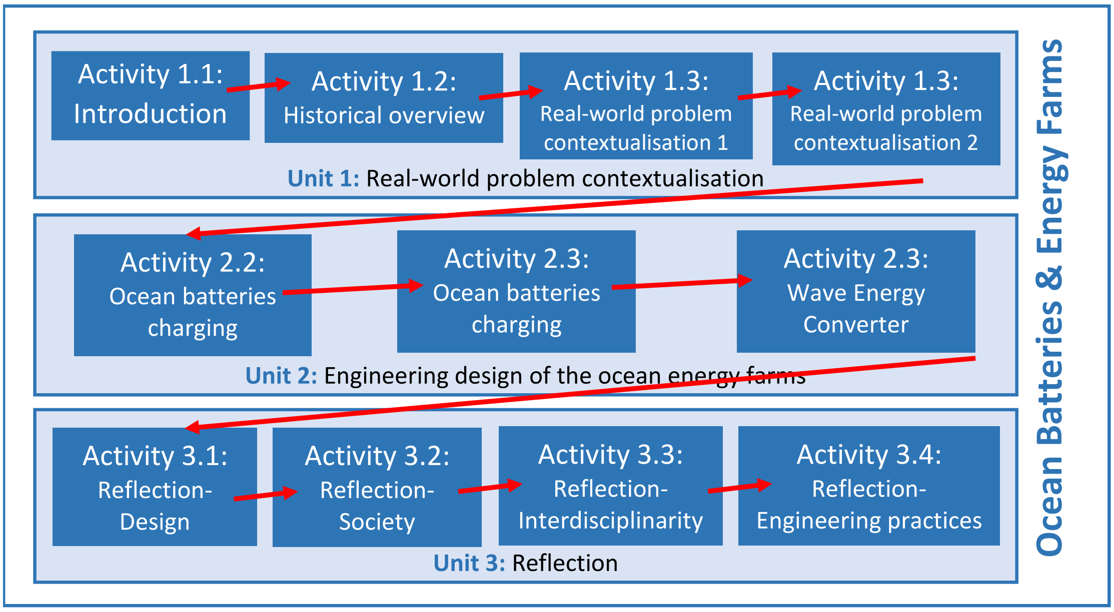

Figure 1: Proposed sequence of activities for the Ocean Batteries and Energy Farms scenario

The constituent activities in each unit are described in the following chapter.

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Chapter 4: Implementation

Unit 1: Real-world problem contextualisation

Activity 1.1: Introduction

In this activity, the participants signup and familiarise themselves with the online gamification platform. They create and customise their own avatar, and identify the avatar of their peers in the same group. They name their group and start exploring the space in order to find the way to access the password for the next level.

> **Hint:**
>
> It is recommended that time and space is devoted so that the participants develop their own style of avatars, names, style, and group name in order to feel some degree of ownership with the scenario and their group, that will motivate them to engage with the scenario.

This activity is recommended to take place synchronously in order to meet all their peers and instructors. It is recommended to take place as teacher-led and online so that the instructor provides some guidance to the participant groups on how to use the platform and the digital technologies (e.g. AR apps).

Links for the digital media used:

gather.town room

https://app.gather.town/invite?token=V-srZl1ETUqtYZP2p_Ye

AR assistant

To be scanned/clicked:

https://mtvrs.io/WobblyOutlyingLionfish

AR assistant dialogue tree overview

https://studio.gometa.io/dimension/experiences/65ee4bf7-9d19-46ab-b982-96c1c114c857/storyboard

Alternative:

The scenario can also take place face-to-face, where the participants use their own devices (e.g. smartphones). Attention should be paid in order to have earphones and the required distance between them so that the connection runs smoothly.

Activity 1.2: Historical overview

In this activity, the participants interact with objects in the game stage which has the scenery of an old river, in order to find prompts and informative texts about the historical evolution of renewable energy sources. At the end of the stage, they have to obtain the password by answering correctly (most of) the questions of the AR assistant (mermaid) in order to get a sufficient score to get the password for the next level. At the end of the stage, they watch a video of 'time-travelling' to the modern age.

Hint:

It is recommended to avoid focusing on too many details included in the texts. The participants should be guided to get the general sense and main information. Also, the mathematical formulas used for expressing ocean energy and power should be qualitatively explored; hence the meaning and definition of power in two axes is the goal of this prompt.

This activity is recommended to take place online asynchronously and student-led since it can give the opportunity to participants to explore the material at their own pace individually.

Links for the digital media used:

To be scanned/clicked:

https://mtvrs.io/DownrightQuarterlyCalf

AR assistant dialogue tree overview https://studio.gometa.io/discover/me/9be373b4-5f17-4204-899d-5119f147283b

video:

https://www.youtube.com/watch?v=rUYoYYHzKOs

Alternative:

The scenario can also take place synchronously in groups and led by the teacher in cases we want to orient discussions about the History and Epistemology of Science.

Activity 1.3: Real-world problematisation 1

The participants enter the 'modern river' stage, and gather information and data regarding the use of renewable energy sources in relation to energy from fossil fuels. They collaboratively reflect on the online whiteboard with peers regarding the real-world problems that using renewable energy sources aims to address. They interact with the AR assistant (seahorse) to get the password for the next part of the river (divided by a bridge).

Hint:

It is recommended to orient the participants in using scientific argumentation based on evidence to support their responses. Discussion about policy reports in the context of renewable energy sources is also recommended.

This activity is recommended to take place online asynchronously and student-led since it can give the opportunity to participants to explore the material at their own pace with their group peers.

Links for the digital media used:

To be scanned/clicked:

https://mtvrs.io/InsignificantBeneficialLeafcutterant

AR assistant dialogue tree overview https://studio.gometa.io/discover/me/4ca75b5e-c0a8-4f67-8c76-9b4fe36fc5c7

Alternative:

The scenario can also take place synchronously in groups and led by the teacher in cases we want to orient the discussion more towards the interaction between policymakers, society and science.

Activity 1.4: Real-world problematisation 2

The participants enter the second part of 'modern river' stage, and, similarly to the previous activity, gather information and data by interacting with objects and reflecting on the online whiteboard. In this stage, they focus on the need for energy storage technology, the ocean batteries and the WEC. They interact with the AR assistant (seahorse 2) to get the password for the next stage through a 'tube'.

Hint:

It is recommended to orient the participants in using scientific argumentation based on evidence to support their responses. It is also recommended to stress the innovation that ocean batteries and WEC bring along.

This activity is recommended to take place online asynchronously and student-led since it can give the opportunity to participants to explore the material at their own pace with their group peers.

Links for the digital media used:

To be scanned/clicked:

https://mtvrs.io/DarkcyanWeeMouflon

AR assistant dialogue tree overview https://studio.gometa.io/discover/me/657b2021-7814-4528-8620-abee0e3b6a4b

Alternative:

The scenario can also take place synchronously in groups and led by the teacher in cases we want to orient the discussion more towards the innovative features of the ocean batteries and WEC.

Unit 2: Engineering design of the ocean batteries and energy farms

Activity 2.1: Ocean Batteries – Charging

The participants enter the main room and use the password found on the board in order to access the ocean batteries charging room. They perform variable testing in order to maximise the efficiency of the ocean battery. They interact with the AR assistant (brain) to get the password for the next room (discharging).

Hint:

The participants should be guided to perform the inquiry steps needed, such as making predictions, collecting and analysing data, making inferences, etc. The logbooks can be used to assist the participants in keeping records of their tests.

This activity is recommended to take place synchronously and student-led so that the participants can experimentise and work in groups for the variable testing. Face-to-face modality is recommended in order to face potential software problems with the simulations.

Links for the digital media used:

- Online platform (gather.town room)

https://app.gather.town/app/TBwxftqZzIV4EyL0/STEM%20Digitalis_training

- AR assistants

Charging

Rigid reservoir

https://mtvrs.io/PalevioletredSpanishBlackbear

Pipeline length

https://mtvrs.io/CelebratedGraciousVixen

Npump

https://mtvrs.io/ZestySuddenBirdofparadise

- AR assessment assistant (password key)

password key Charging

https://mtvrs.io/LightyellowPlainAustralianshelduck

Alternative:

The scenario can also take place online synchronously in groups in cases we want (or in cases that it is needed that) the participants to work remotely with peers.

Activity 2.2: Ocean Batteries – Discharging

The participants enter the discharging room and they perform variable testing in order to maximise the efficiency of the ocean battery for the discharging process. They interact with the AR assistant (brain) to get the password for the next room (WEC).

Hint:

The participants should be guided to perform the inquiry steps needed, such as making predictions, collecting and analysing data, making inferences, etc. The logbooks can be used to assist the participants in keeping records of their tests.

This activity is recommended to take place synchronously and student-led so that the participants can experimentise and work in groups for the variable testing. Face-to-face modality is recommended in order to face potential software problems with the simulations.

Links for the digital media used:

- Online platform (gather.town room)

https://app.gather.town/app/TBwxftqZzlV4EyL0/STEM%20Digitalis_training

- AR assistants

Discharging

Depth

https://mtvrs.io/EducatedSlowArgali

Nturbine

https://mtvrs.io/WordyClosedArabianhorse

Dis pi L

https://mtvrs.io/DimActualBarnacle

- AR assessment assistant (password key)

password key Discharging

https://mtvrs.io/HoarseIndelibleHyrax

Alternative:

The scenario can also take place online synchronously in groups in cases we want (or in cases that it is needed that) the participants to work remotely with peers.

Activity 2.3: Wave Energy Converter (WEC)

The participants enter the Wave Energy Converter (WEC) room and they perform variable testing in order to maximise the efficiency of the WEC. They also run the simulation that visualises the motion of a floater. They can also (optionallly) experience an additional room regarding variable testing concerning the efficiency of a wind turbine. They interact with the AR assistant (brain) to get the password for the next room (Wind turbine or Reflection room).

Hint:

The participants should be guided to perform the inquiry steps needed, such as making predictions, collecting and analysing data, making inferences, etc. The logbooks can be used to assist the participants in keeping records of their tests. The password for the wind turbine room is the same as the password for the reflection room; therefore, the instructors could skip the wind turbine if needed.

This activity is recommended to take place synchronously and student-led so that the participants can experimentise and work in groups for the variable testing. Face-to-face modality is recommended in order to face potential software problems with the simulations.

Links for the digital media used:

- Online platform (gather.town room)

https://app.gather.town/app/TBwxftqZzlV4EyL0/STEM%20Digitalis_training

- AR assistants

Wave Energy Converter (WEC)

WEC-Intro

https://mtvrs.io/AttentiveVictoriousGuillemot

WEC-variable testing

https://mtvrs.io/LightpinkPlumStarling

- AR assessment assistants (password keys)

password key-WEC

https://mtvrs.io/EminentFarawaySolenodon

password key-Wind turbine

https://mtvrs.io/EntireTatteredAndalusianhorse

Alternative:

The scenario can also take place online synchronously in groups in cases we want (or in cases that it is needed that) the participants to work remotely with peers.

Unit 3: Reflection

Activity 3.1: Reflection-Design

The participants enter a virtual room (living room), where they are called upon to reflect on the optimal design of the Ocean Batteries and Energy Farms model that they experienced. In specific, they discuss the inferences they had made and write down their conclusions on the online whiteboard.

Hint:

It is recommended that the instructor gives the opportunity to every participant to express their views. The participants should be encouraged to discuss critically without the fear of making mistakes. Collaboration and reflection between peers should become the norm.

This activity is recommended to take place online synchronously and teacher-led so that the instructor acts as a facilitator of the discourse. Discussion is recommended to take place in small groups.

Links for the digital media used:

- Online platform (gather.town room)

https://app.gather.town/app/TBwxftqZzlV4EyL0/STEM%20Digitalis_training

- Online whiteboard (embedded)

https://app.gather.town/app/TBwxftqZzlV4EyL0/STEM%20Digitalis_training

Alternative:

The scenario can also take place face-to-face synchronously in groups in cases where the online discussion turns out to be not so participatory and we want to persuade the participants to participate more actively or in cases where we would like multiple participants to discuss simultaneously with their peers.

Activity 3.2: Reflection-Society

The activity takes place in the same virtual room as before (living room), and the participants are called upon to reflect on socioscientific issues related to the scenario. In specific, they are called upon to discuss the impact of this technology from the perspective of science, society, policymakers, industry, etc. They are prompted to write down their views on the second embedded online whiteboard in the virtual room.

Hint:

It is recommended that the instructor gives the opportunity to every participant to express their views. The participants should be encouraged to discuss critically without the fear of making mistakes. It is important to encourage the participants to express and discuss their own views and perspectives instead of passively following the group's opinion. Collaboration and reflection between peers should become the norm.

This activity is recommended to take place online synchronously and teacher-led so that the instructor acts as a facilitator of the discourse. Discussion is recommended to take place in small groups.

Links for the digital media used:

- Online platform (gather.town room)

https://app.gather.town/app/TBwxftqZzlV4EyL0/STEM%20Digitalis_training

- Online whiteboard (embedded)

https://app.gather.town/app/TBwxftqZzlV4EyL0/STEM%20Digitalis_training

Alternative:

The scenario can also take place face-to-face synchronously in groups in cases where the online discussion turns out to be not so participatory and we want to persuade the participants to participate more actively or in cases where we would like multiple participants to discuss simultaneously with their peers.

Activity 3.3: Reflection-Interdisciplinarity

The participants proceed to the second virtual room (living room 2), where they are called upon to reflect on disciplinary and interdisciplinary aspects that they came across while experiencing the digital scenario. They are prompted to reflect on interconnections between the disciplines and to express their views on whether that could be considered an obstacle for learning. Similarly to before, they can write down their conclusions on the embedded online whiteboard.

Hint: It is recommended that the instructor gives the opportunity to every participant to express their views. The participants should be encouraged to discuss critically without the fear of making mistakes. Collaboration and reflection between peers should become the norm.

This activity is recommended to take place online synchronously and teacher-led so that the instructor acts as a facilitator of the discourse. Discussion is recommended to take place in small groups.

Links for the digital media used:

- Online platform (gather.town room)

https://app.gather.town/app/TBwxftqZzlV4EyL0/STEM%20Digitalis_training

- Online whiteboard (embedded)

https://app.gather.town/app/TBwxftqZzlV4EyL0/STEM%20Digitalis_training

Alternative: The scenario can also take place face-to-face synchronously in groups in cases where the online discussion turns out to be not so participatory and we want to persuade the participants to participate more actively or in cases where we would like multiple participants to discuss simultaneously with their peers.

Activity 3.4: Reflection-Engineering practices

The activity takes place in the same virtual room as before (living room 2), and the participants are called upon to reflect on engineering practices, based on what they have experienced in the digital scenario. In specific, they are called upon to discuss epistemologically about the profession of an engineer, its characteristic aspects, and the practices that engineers use.

They are prompted to write down their views on the second embedded online whiteboard in the virtual room.

Hint:

It is recommended that the instructor gives the opportunity to every participant to express their views. The participants should be encouraged to discuss critically without the fear of making mistakes. Collaboration and reflection between peers should become the norm. It is also recommended to demonstrate role models of engineers, especially from underrepresented groups and discuss about them, the potentialities and the challenges that they may have come across in their careers.

This activity is recommended to take place online synchronously and teacher-led so that the instructor acts as a facilitator of the discourse. Discussion is recommended to take place in small groups.

Links for the digital media used:

- Online platform (gather.town room)

https://app.gather.town/app/TBwxftqZzIV4EyL0/STEM%20Digitalis_training

- Online whiteboard (embedded)

https://app.gather.town/app/TBwxftqZzIV4EyL0/STEM%20Digitalis_training

Alternative:

The scenario can also take place face-to-face synchronously in groups in cases where the online discussion turns out to be not so participatory and we want to persuade the participants to participate more actively or in cases where we would like multiple participants to discuss simultaneously with their peers.

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