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EDUCATOR GUIDE

- Water -

PART OF THE INTELLECTUAL OUTPUT 3

Responsible partner: DCU

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Table of contents

Chapter 1: Introduction

This document serves as an Educator's Guide for the implementation of the Water scenario.

It contains an overview of the Water scenario structure and after that a detailed description of each individual unit and 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 types 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

Moreover the Educator's Guide includes hints for the instructors, indicating possible pre-service teachers' difficulties and ways to help them overcome them. These hints are indicated by 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, for example if someone wants to implement the Water digital scenario fully on-line, are also provided. These alternatives are indicated by 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 Water education

Water is a basic resource, required by all society to survive and thrive. While advancements in science and engineering over the past two centuries has allowed populations to avail of greater water security, in 2016, the United Nations International Resource Panel reported that "without altering current levels of water consumption and pollution, almost half of the world's population will suffer severe water stress by 2030, thereby damaging the well-being of millions of people". If the world is to stave off a looming water crisis, water use needs to be decoupled from economic growth. There is no single way to do so, rather a multi-pronged approach is required, which will focus on reducing water waste, reducing water pollution, better protection of water-based ecosystems and recognition of the water footprint of different goods and services. These changes are required at a societal level - from big industry all the way down to the individual - and so the education system will be a key player in driving this change.

Water education is crucial for pre-service teachers and science educators as society addresses this looming crisis. Teachers have a significant role in shaping future generations' perspectives and knowledge. By equipping pre-service teachers with water education, we empower them to effectively educate their students.

For science educators, understanding the science of water is fundamental as they play a role in nurturing scientific literacy. Ensuring that science teachers possess comprehensive knowledge of water is essential for delivering accurate and thorough instruction on the subject.

Water education should not merely focus on the problem but also emphasize solutions. By understanding mitigation strategies, pre-service teachers can support students to identify ways in which they can take personal and collective action to support water sustainability. Teachers have an ethical responsibility to prepare students to be responsible global citizens.

Ultimately, water education empowers teachers to empower their students. It fosters critical thinking skills, informed decision-making, and active engagement in discussions and actions that can drive positive change.

Chapter 3: Structure of the Digital Scenario

The Water scenario consists of three units:

- Unit 1: Water sustainability and awareness
- Unit 2: Water data and Analysis
- Unit 3: Water monitoring and citizen science

In Unit 1, pre-service teachers are introduced to the importance of water awareness and water sustainability. They learn about the water cycle through hands-on investigation and develop their ability to write causal explanations of real-world phenomena. They explore water use and waste through the water footprint concept and identify personal action they can take to reduce water waste.

In Unit 2, pre-service teachers explore water data and how it may be used to inform our understanding of our impact on water-based habitats and environments. In doing so students analyse data collected in Dublin port and develop their data literacy. Complementing this, pre-service teachers use pH sensors to collect their own data and to understand the origins and impact of acid rain.

In Unit 3, pre-service teachers are introduced to the topic of Citizen Science and how it's used to support science research projects and to engage the public with STEM. They learn about one project which is based around Citizen Science - Freshwater Watch - and contribute to this work by collecting their own water data from a local freshwater source.

At the end of each unit, pre-service teachers are asked to reflect on their learning, in terms of the scientific concepts and the pedagogies utilised. This is intended to support pre-service teachers' wider development as teachers of STEM and to inculcate the habit of critical reflection.

The three units comprise an extensive array of activities which are designed to be used and adapted by educators as per their needs. While all the activities may be completed in full (see Figure 1), it is also possible to select a subset of activities, to reorder activities, to implement activities using different approaches and to supplement activities with your own. Some sample learning sequence are presented in Figure 2 .

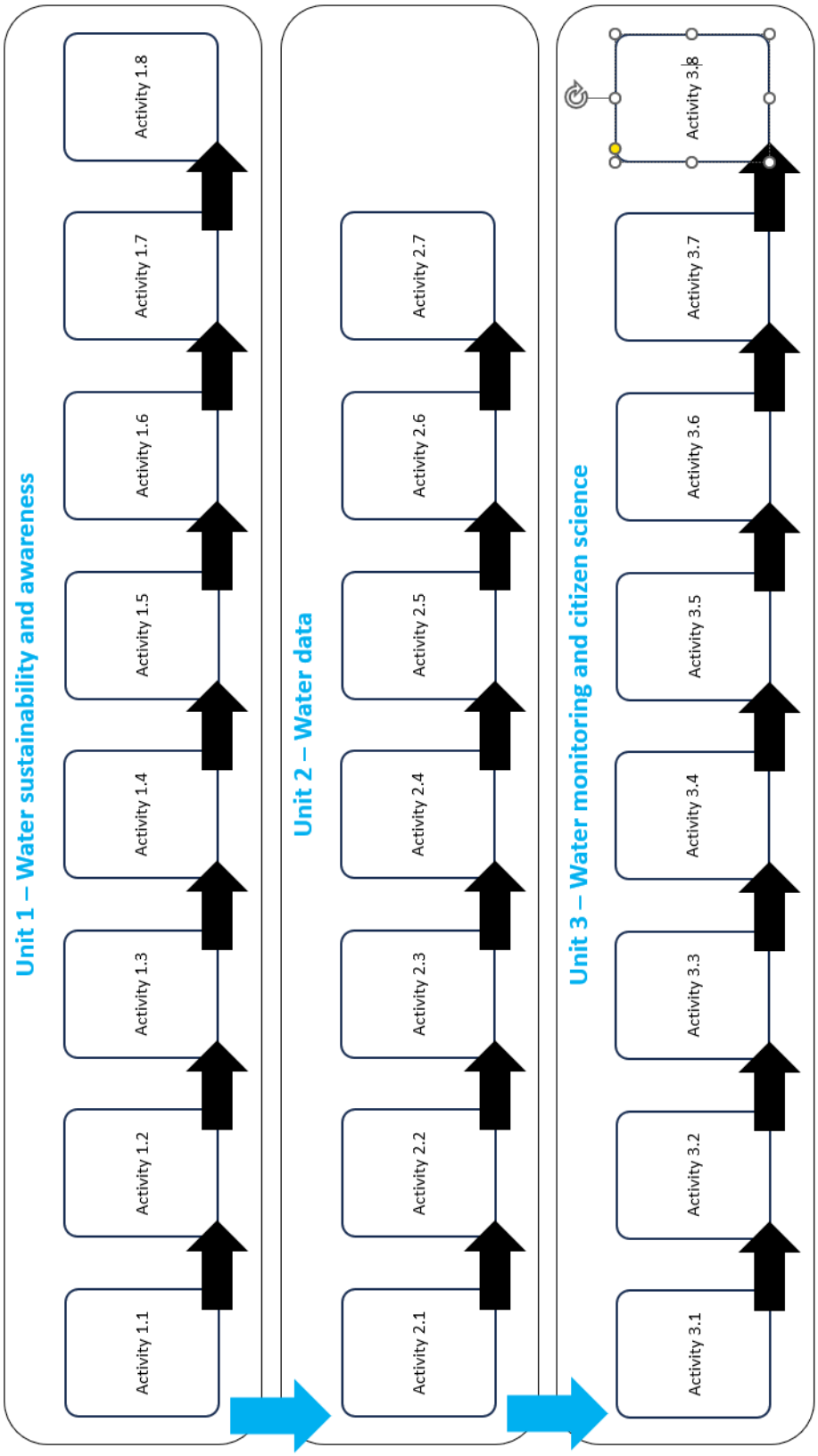

Figure 1. The sequence of activities when teaching the three units in full.

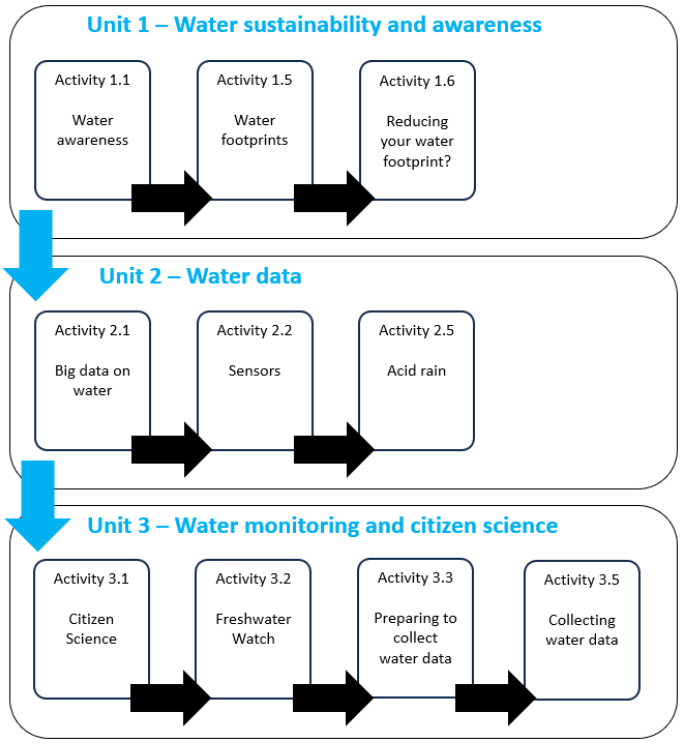

Figure 2 - One possible sequence for the digital scenario of water, which uses a subset of the full set of activities.

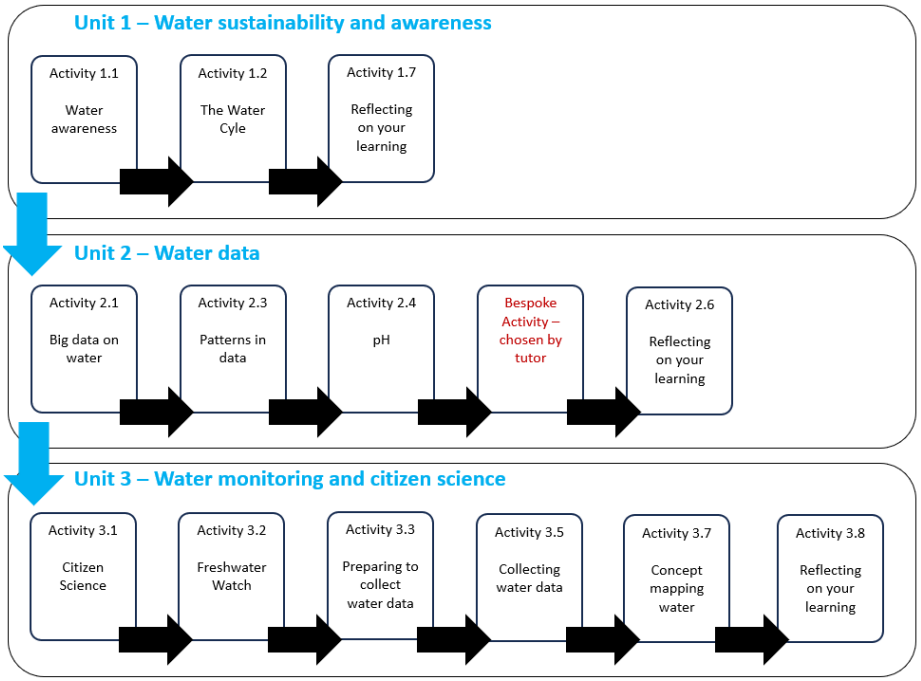

Figure 3 - One possible sequence for the digital scenario of water. This sequence includes an external activity - chosen by the tutor, in line with the needs of their own curriculum.

Chapter 4: Implementation

Unit 1: Water sustainability and awareness

Activity 1.1

This activity is intended to engage students with the issue of freshwater scarcity, compared to the abundance of surface water on earth. Students calculate what volume of a 1L bottle of water would represent the proportion of the earth's surface water which is freshwater, if the 1L bottle represents all the earth's surface water.

Activity 1.1 is teacher led and it's suggested that it is run in a synchronous, face-to-face session. Students work together in groups and develop their understanding through discussion and comparison of solutions.

Hint:
This activity is a good opportunity to discuss how to incorporate numeracy development into STEM activities and the importance of having a positive attitude to numeracy. The use of comparative volumes allows students to better understand proportions, compared to dealing with the huge figures involved in describing the volume of surface water on earth.

Alternative:
Activity 1 could be conducted in an online, synchronous mode, using a suitable teleconference application.. In such a case, students could work together in separate virtual rooms, before sharing findings back in the main room.

Digital media used during this activity include:

- Unit 1 Presentation

Activity 1.2

This is a multifaceted activity which focuses on students developing their ability to write causal explanations of the processes involved in the water cycle. Students work in small groups on one water-cycle process, by writing an initial causal explanation of that process. Students develop their understanding of their process by engaging in an investigative task, before receiving information on how to construct causal explanations. Each group then

updates their causal explanation of their water-cycle process. Students share their learning by forming super groups made up of four separate groups (one for each water cycle process) and presenting their work. Each group further refines their causal explanations based on feedback from this and shares their work on a Google Jamboard.

Activity 1.2 is suggested to be conducted in a synchronous, face-to-face setting. Students work in groups and while the session is mainly student-led, there are points where teacher input is important (discussion of causal explanations).

Hint:
This activity is rich in student-centred pedagogies, where the teacher acts more as a facilitator than instructor. It may be worthwhile asking students to reflect on the pedagogies used and what their experience of them was.

Alternative:
This activity could take place online as the materials needed are easily sourced and students could be asked to have them ready in advance. Group work could be facilitated through the use of virtual rooms.

Digital media used during this activity include:

- Presentation
- Google Jamboard
- Digital worksheet for investigating evaporation
- Digital worksheet for investigating condensation
- Digital worksheet for investigating precipitation
- Digital worksheet for investigating collection

Activity 1.3

Students create a mind map, to summarise their current knowledge/understanding of water and share their work with the rest of the class using a Google Jamboard. Students further develop their understanding of water by investigating changes of state using an online simulation.

Activity 1.2 is presented here as an asynchronous activity which can be conducted as group or individual work. In the case of students working together in groups, they could do so face-to-face or using an online platform. The activity is student led.

Hint:
The teacher could also use the mind maps to assess students' knowledge, by asking probing questions related to different parts of their maps.This could then be used to guide the subsequent learning of the group.

Digital media used during this activity include:

- Mind mapping software
- Google Jamboard
- Simulation Activity

Activity 1.4

Students engage with a number of media sources to stimulate their thinking around water conservation and the impact of climate change on water security. Students are asked to estimate how much freshwater they flush down the toilet each day as a means to encourage personal reflection on their water consumption.

Activity 1.4 is presented here as a teacher-led discussion, which takes place in a face-to-face, synchronous setting. Students work individually first, before sharing their findings in small groups and then with the whole class.

Hint:
This activity is designed to get students invested in the topic of water conservation. This is done by making the calculation personal to them. There is an opportunity here to look for trends in the results of the water estimation activity. Do boys/girls flush more water down the toilet?

Alternative:
This activity could easily be facilitated in an online session. To enable group work, virtual rooms could be employed. With some pre-planning students could be asked to track their toilet habits over the course of an entire day.

Digital media used during this activity include:

- Unit 1 Presentation
- Video 1
- Video 2

Activity 1.5

The notion of water use/wastage is further highlighted in this activity as students learn about the water footprint concept, before completing a three-stage task where they:

- Estimate the water footprint of different foods
- Calculate the water footprint of different lunch options
- Calculate their own water footprint

Each of these tasks include questions designed to stimulate students' thinking on key contributors to water footprints. The teacher uses the answers to these questions to facilitate further discussion amongst the group as a whole.

Activity 1.5 is student led, with the teacher acting as a facilitator/guide. The activity is conducted synchronously, in a face-to-face setting and involves students working in small groups.

Hint:
When students calculate the water footprints of different lunch boxes and rank them in order, it is likely that the ranking will be different for each group. This is due to the fact that students have to source some water-footprint information for themselves and that they have to make judgement calls on portion sizes. This is a good opportunity for the teacher to discuss the reliability of data sources and the idea of a fair comparison.

Alternative:
This activity could easily be facilitated in an online session. To enable group work, virtual rooms could be employed.

Digital media used during this activity include:

- Unit 1 Presentation
- Water footprint information video
- Digital worksheet
- Reducing your water footprint video
- Water footprint data

Activity 1.6

This activity asks students to summarise their learning around water footprints, water use and water wastage by discussing two questions:

- What are the main contributors to the water footprint of food?
- How can you reduce your own water footprint?

The activity is designed to promote personal accountability and action in relation to water use / wastage. Students share their ideas on a Google jamboard and the teacher facilitates a group discussion.

Activity 1.6 operates in a face-to-face, synchronous setting. Students work individually to start with before sharing their ideas and participating in a whole-group discussion. The activity is student led.

Hint:
The teacher could return to this discussion at a later date and ask students if they made any changes to their lives in light of their learning around water use/waste.

Alternative:
This activity could easily be facilitated in an online session. To enable group work, virtual rooms could be employed.

Digital media used during this activity include:

- Google Jamboard

Activity 1.7

Students are asked to reflect on their learning throughout the module, by completing a digital learning log and sharing it with their tutor. Students are encouraged to reflect on their learning of scientific concepts, the teaching, learning and assessment strategies used and how the learning aligns with their curriculum.

Activity 1.7 is conducted asynchronously, online, is student led and involves students working on an individual basis.

Hint:
As pre-service teachers, the habit of reflection is an important one to inculcate. These reflections are intended to be personal and students can opt to share/not share them with their tutor.

Digital media used during this activity include:

- Digital Learning Log

Unit 2: Water data and Analysis

Activity 2.1

Students are provided with a brief introduction to data literacy and its importance in the 21st century world. Students work in small groups to familiarise themselves with a free, online data-analysis/graphing platform before using this platform to investigate data pertaining to water quality, recorded in Dublin Port over a period of one month. Students answer a variety of questions and in doing so develop techniques for handling large volumes of data. Students share their work with the whole class and the teacher facilitates a discussion on the challenges of interpreting big data and productive strategies for doing so.

Activity 2.2 is student led, and is conducted synchronously, in a face-to-face setting. Students work in pairs to familiarise themselves with the data-analysis platform and to analyse a large set of data.

Hint:
In a similar way to literacy underpinning equality of opportunity in the 20th century, in a modern world which is so reliant on data, numeracy and data literacy are critical competencies, which all citizens should have. Life choices around health, finance and politics require a basic level of data literacy and data literacy is a key component in fighting misinformation and fake news.

Alternative:
This activity could be facilitated in an online setting. While the tasks could also be completed on an individual basis, we suggest that working in pairs will help all students to develop their data literacy at a faster pace.

Digital media used during this activity include:

- Unit 2 Presentation
- CODAP
- CODAP Tutorial 1
- CODAP Tutorial 2
- CODAP Data File on Dublin Port
- Google Jamboard

Activity 2.2

Students explore the use of digital sensors for collecting data. As part of this process they research what the data produced by the sensors tells us about an aquatic environment and how the sensors work to measure a variety of parameters. Students share their findings with the whole group via a Google Jamboard.

Activity 2.2 is conducted face-to-face, synchronously and is student led. Students work in groups to complete the activity, while the teacher acts as a guide. The teacher concludes the activity by facilitating a discussion and summarising the learning.

Hint:
For students to be data and scientifically literate, it is important that they understand what the data collected by digital sensors means, the limitations of such instruments and the mechanisms by which sensors measure a given parameter. With the move towards an increasingly digital world, there is a danger that students develop a "back box" mentality with regard to how technology works.

Alternative:
This activity could easily be facilitated in an online setting, with individual students within a group being assigned one sensor to research, before coming back together with their group to share learning around all sensors.

Digital media used during this activity include:

- Unit 2 Presentation
- Information Sources
- Google Jamboard

Activity 2.3

In Activity 2.3 students carry out further analysis of Dublin Port data, to look for evidence of patterns in the data which may be attributed to either natural or human-induced cycles. Students apply the skills they developed in Activity 2.1 to complete this investigation. Students share their findings with the whole class via a Google Jamboard and engage in a discussion around the different patterns observed.

Activity 2.3 is conducted asynchronously and in an online setting. Students have the option of working in groups or individually. The activity is student led, with the teacher acting as a facilitator using questioning to deepen student understanding. The teacher leads a discussion on students' findings to complete the activity.

Hint:
Activity 2.3 presents a number of opportunities to develop data literacy. Students may struggle to identify patterns in the data which are not simple (e.g. changes in two parameters at the same time), versus patterns which involve a time-lag. This activity also presents an opportunity to discuss correlation versus causation.

Alternative:
This activity could be facilitated in a face-to face setting.

Digital media used during this activity include:

- CODAP Data File on Dublin Port
- Google Jamboard

Activity 2.4

Students learn about pH, via a teacher-led presentation and series of videos. As part of this activity, students explore what pH means in terms of the chemical reactivity of water. why pH is an important measure of the health of an aquatic ecosystem and how pH sensors work.

Activity 2.4 is teacher led, and is conducted synchronously, in a face-to-face setting. Students work in groups to understand the intricacies of the pH scale

Hint:
It is important that students are supported to go beyond a basic understanding of the pH (which focuses mainly on its measurement, the use of the pH scale and the pH values of common household and laboratory chemicals) and to understand how pH relates to the chemical make-up of an aquatic solution. There is also an opportunity to promote numeracy here, in exploring the fact that the pH scale is logarithmic. This may be done by getting students to consider what a unit change in pH value means in terms of the concentration of Hydrogen ions in a solution.
It is also important that students understand how digital pH probes work including their limitations and need for careful maintenance.

Alternative:

This activity could be facilitated in an online setting and students could work on it asynchronously. In such cases it is important that the teacher subsequently leads a discussion which highlights key points of learning.

Digital media used during this activity include:

- Unit 2 Presentation
- Video 1 - Dissociation of water
- Video 2 - Atomic view of pH
- Video 3 - How a pH probe works

Activity 2.5

Students carry out an experimental investigation into the nature of acid rain. In part 1 of the activity, students model the natural acidity of rainwater by blowing into a sample of distilled water and measuring the resultant change in pH. This experiment demonstrates the limited effect that CO_2 absorption has on reducing the pH of rainwater. In part 2 of the activity, students model the effect of acid rain on different water samples by adding dilute H_2SO_4 to samples of water taken from different bodies and measuring the resultant change in pH. In doing so, students learn about the buffering potential of different water sources and what this means in terms of the impact of acid rain on different bodies of water. The teacher acts as a guide throughout the activity, asking probing questions and checking for understanding.

Activity 2.5 is student led, and is conducted synchronously, in a face-to-face setting. Students work in groups to complete the activity.

Hint:
This activity provides students with the chance to carry out an experimental investigation using pH probes and dataloggers. The quality of data collection is greatly affected by the correct use of the pH probe. In this regard, students' learning about pH and pH probes in Activity 2.4 is important to bring forward here.
Data collected in part 1 of the experiment is sensitive to the volume of water used, the rate at which students blow into the sample and the correct cleaning of the probe prior to use.
The pattern in the data collected in part 2 of the experiment can be difficult to see. By examining the overall change in pH for each water sample, it is easier to identify which water sample has more buffering potential.
Part 2 of the activity can be conducted to allow students to develop their skills in designing a fair test, prior to giving them detailed instructions on how to use the probe and data logger to collect the necessary data.

Alternative:
This activity must be carried out in a laboratory setting due to the requirement of hazardous chemicals and pH probes and data loggers.

Digital media used during this activity include:

- Digital worksheet
- Article on natural buffers
- Video on natural buffers

Activity 2.6

Students are asked to reflect on their learning throughout the module, by completing a digital learning log and sharing it with their tutor. Students are encouraged to reflect on their learning of scientific concepts, the teaching, learning and assessment strategies used and how the learning aligns with their curriculum.

Activity 2.6 is conducted asynchronously, online, is student led and involves students working on an individual basis.

Hint:
As pre-service teachers, the habit of reflection is an important one to inculcate. These reflections are intended to be personal and students can opt to share/not share them with their tutor.

Digital media used during this activity include:

- Digital Learning Log

Unit 3: Water monitoring and Citizen Science

Activity 3.1

In activity 3.1, students learn about Citizen Science by engaging with a presentation. To assess their learning, students complete an online quiz.

Activity 3.1 is teacher led, and is conducted synchronously, in a face-to-face setting. Students work individually to complete the quiz.

Alternative:
This activity could also be carried out synchronously, in an online setting.

Digital media used during this activity include:

- Unit 3 Presentation
- Online quiz

Activity 3.2

In Activity 3.2 students learn about the Freshwater Watch project and DCU Water Institute's BACKDROP Project by exploring their websites.

Activity 3.2 is conducted asynchronously and in an online setting and is student led.

Alternative:
This activity could be facilitated in a face-to face setting.

Digital media used during this activity include:

- Freshwater Watch website
- Freshwater Watch Overview Video
- BACKDROP Project

Activity 3.3

In Activity 3.3 students prepare for collecting water data. Students sign up for an earthwatch community account. Once they log into their account, they search for a local Freshwater Watch event and sign up to participate. Once they do so they will be able to request testing kits and engage in a series of tutorials to prepare them for carrying out their data collection. As part of this process, students install the ArcGIS Survey 123 app on their phone which will allow them to record and upload the data they collect. Students discuss how to work safely near bodies of water by engaging with a safety presentation. Students check their learning by completing an online quiz.

Activity 3.3 is conducted synchronously, in an online setting and is teacher led. Students work in groups to prepare for collecting their water data.

Hint:
Activity 3.3 may need to be completed over an extended period of time. It is probably best if the tutor identifies a local Freshwater Watch group in advance, makes contact with them and acquires the requisite number of water testing kits. Alternatively the tutor could establish their own Freshwater Watch community group (there is a cost to doing so). It is important that students get the opportunity to trial the water-testing kits prior to carrying out their data collection.
The Freshwater Watch tutorials are not accessible to the public. You may only access them after setting up an Earthwatch Community account and signing up for a Freshwater Watch group or event.
It is important that all students are aware of how to operate safely when collecting their water data.

Alternative:
This activity could be facilitated in an online setting, provided students are given a water testing kit in advance of doing so.

Digital media used during this activity include:

- Unit 3 Presentation
- Web form for setting up an Earthwatch account
- Online quiz

Activity 3.4

In Activity 3.4 students learn about the impact of Freshwater Watch projects by examining a number of case studies from Ireland. Students search for similar projects which have taken place close to them and discuss what the data collected tells them about their local freshwater bodies. Students check their learning by completing an online quiz.

Activity 3.4 is conducted synchronously, face to face and is student led. Students work in groups to explore the case studies and to find similar studies which are local to them.

Hint:
Activity 3.4 allows students to further understand the data collected by Freshwater Watch projects and how this informs our understanding of our local freshwater bodies.
Students are encouraged to find similar projects which are local to them, with the aim of making this work more personal to them and encouraging action.

Alternative:
This activity could be facilitated in an online setting. In such a setting, group work could be facilitated using virtual rooms on the chosen platform.

Digital media used during this activity include:

- Unit 3 Presentation
- Freshwater Watch Website
- Online quiz

Activity 3.5

In Activity 3.5 students work in groups to collect data on a local freshwater body. They record the data using the ArcGIS Survey123 app and upload their results to the Freshwater Watch database for further analysis. Students check back on their Freshwater Watch community page after a number of weeks to explore how their work contributed to the overall project.

Activity 3.5 is conducted asynchronously, face to face and is student led. Students work in groups to collect data.

Hint:
Activity 3.5 allows students to apply their scientific skills to record real data and to contribute to a research project. For the fidelity of the project, students must understand the importance of carrying out accurate and precise measurements.

Digital media used during this activity include:

- Freshwater Watch website

Activity 3.6

In Activity 3.6 students discuss the potential for Citizen Science to engage students with STEM learning and to engage the general public with STEM-related issues. Students identify other areas where Citizen Science could be utilised and share these with the whole class using a Google Jamboard.

Activity 3.6 is conducted synchronously, face to face and is student led.

Alternative:
This activity could be facilitated in an online setting..

Digital media used during this activity include:

- Google Jamboard

Activity 3.7

In Activity 3.7 students revisit Activity 1.3, where they created a mind map to summarise their knowledge pertaining to water. In this activity students learn about concept maps, how they are different to mind maps and how they facilitate a much deeper understanding of a given topic. Students engage with resources on the Cmap website and utilise the free mapping app therein to construct a concept map which summarises their learning across the three units.

Activity 3.7 is conducted synchronously, face to face and is student led. Students work individually to create their concept maps before sharing and discussing their approaches.

Hint:
Activity 3.7 provides a good opportunity to revisit learning from across the entire scenario and to provide students with a skill which may be used when studying any STEM topic.

Alternative:
This activity could be facilitated in an online setting.

Digital media used during this activity include:

- Cmap website

Activity 3.8

Students are asked to reflect on their learning throughout the module, by completing a digital learning log and sharing it with their tutor. Students are encouraged to reflect on their learning of scientific concepts, the teaching, learning and assessment strategies used and how the learning aligns with their curriculum.

Activity 3.8 is conducted asynchronously, online, is student led and involves students working on an individual basis.

Hint:
As pre-service teachers, the habit of reflection is an important one to inculcate. These reflections are intended to be personal and students can opt to share/not share them with their tutor.

Digital media used during this activity include:

- Digital Learning Log