



Ark of Inquiry: Inquiry Activities for Youth over Europe

Deliverable D2.2

# **Pedagogical inquiry scenarios for re-use of inquiry activities – initial**

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## Summary

The Ark of Inquiry project aims to build a scientifically literate and responsible society through inquiry-based science education. The project seeks to expand young people's awareness of Responsible Research and Innovation (RRI) by disseminating across Europe engaging inquiry activities in Science, Technology, Engineering and Mathematics (STEM) domains.

The current deliverable describes Pedagogical Scenarios that are designed to help teachers (and others) across Europe to implement, adapt and reuse inquiry activities in their classrooms in the context of the Ark of Inquiry project. The need for the scenarios stems from the fact that the focus within the Ark of Inquiry project is on pre-existing inquiry activities, which have not been designed specifically for the Ark of Inquiry. In this respect, the pedagogical scenarios can be considered as means (or pedagogical tools) to bridge the gap between existing activities and the requirements for use in the Ark of Inquiry. The underlying idea of the Pedagogical Scenarios is that teachers should be supported in taking ownership of the activities and in developing professional competencies in order for them to be able to adapt activities to their (unique) educational goals.

The deliverable presents five initial pedagogical scenarios that are designed to enhance the uptake and use of inquiry activities across schools in Europe in the context of the Ark of Inquiry project.

- Scenario 1: Introduction to the Inquiry Model of the Ark of Inquiry Project
- Scenario 2: Changing the Proficiency Level
- Scenario 3: Adding Inquiry Phases
- Scenario 4: Improving Gender Inclusion
- Scenario 5: Overcoming Language Barriers

The scenarios build on the existing work in the project and are generic in nature, meaning that each scenario can be implemented in relation to any inquiry activity inside and outside of the project where the scenario applies to. The scenarios are targeted at teachers with an idea that the scenarios will help them to author, amend and adapt existing activities to fit these better to their specific needs and goals in the school environment. Even though the scenarios are targeted at teachers, they can also be used by other stakeholders to help them design and structure activities in such manner that the activities meet the general requirements of the Ark of Inquiry project. As the project evolves, based on experiences in and feedback from the teacher training and piloting this initial pedagogical framework will be continuously revised and amended, and a final updated version of the framework, with broader scope of scenarios, will be presented in M24 (D2.4 Pedagogical inquiry scenarios for re-use of inquiry activities). The scenarios in this deliverable will also be a component in the Ark of Inquiry's support system (D1.4 Specification of support systems in Ark of Inquiry) and can be used by teachers

to adapt and/or amend activities when they work with these activities during teacher training (WP4) in the Ark of Inquiry project.

# Table of Contents

<b>1. INTRODUCTION.....</b>	<b>7</b>
<b>2. PEDAGOGICAL SCENARIOS .....</b>	<b>9</b>
SCENARIO 1: INTRODUCTION TO THE INQUIRY MODEL OF THE ARK OF INQUIRY PROJECT ....	9
SCENARIO 2: CHANGING THE PROFICIENCY LEVEL .....	14
EXAMPLE 1: ELECTRICITY LAB .....	15
EXAMPLE 2: THE WADDENZEE FISH MONITOR.....	20
SCENARIO 3: ADDING INQUIRY PHASES.....	26
EXAMPLE 1: THE ELECTRICITY LAB .....	27
EXAMPLE 2: OUR ACIDIFYING OCEAN .....	30
SCENARIO 4: EMPOWERING GIRLS IN SCIENCE .....	33
SCENARIO 5: OVERCOMING LANGUAGE BARRIERS .....	36
<b>3. CONCLUSIONS.....</b>	<b>38</b>
<b>REFERENCES .....</b>	<b>39</b>

# 1. Introduction

The Ark of Inquiry project aims to build a scientifically literate and responsible society through inquiry-based science education. The project seeks to expand young people's awareness of Responsible Research and Innovation (RRI) by disseminating across Europe engaging inquiry activities in Science, Technology, Engineering and Mathematics (STEM) domains.

The current deliverable describes Pedagogical Scenarios that are designed to help teachers (and others) across Europe to implement, adapt and reuse inquiry activities in their classrooms in the context of the Ark of Inquiry project. The need for the scenarios stems from the fact that the focus within the Ark of Inquiry project is on pre-existing inquiry activities, which have not been designed according to the principles that are fundamental and unique to Ark of Inquiry, meaning that most of the existing activities might not fit optimally into the context of Ark of Inquiry. This was anticipated in the DoW and confirmed in the initial review of inquiry activities, conducted in the context of deliverable D2.3 (Population of the Ark of Inquiry platform for piloting), which identified a need for adjustments in many potentially interesting activities before they could be used effectively in the classrooms across Europe within the framework of the Ark of Inquiry. In this respect, the pedagogical scenarios can be considered as means (or pedagogical tools) to bridge the gap between existing activities and the requirements for use in the Ark of Inquiry. The underlying idea of the Pedagogical Scenarios is that teachers should be supported in taking ownership of the activities and in developing professional competencies in order for them to be able to adapt activities to their (unique) educational goals.

This document represents five initial pedagogical scenarios, outlined below. The choice for the initial scenarios is based on the aims of the project as formulated in the DoW; the definition of the Framework for Inquiry Proficiency in D1.1 Description of inquiry approach that fosters societal responsibility; activities performed in the context of WP2 (D2.1 – Criteria for selection of inquiry activities including societal and gender dimensions, and initial work for D2.3 – Population of the Ark of Inquiry platform for piloting); and analysis of connections with tasks/deliverables in other WPs (D1.4 Specification of support systems in Ark of Inquiry and D4.2 Teacher training materials). The scenarios will be presented in detail in the forthcoming chapters. As the project evolves, based on experiences in and feedback from the teacher training and piloting, this initial pedagogical framework will be continuously revised and amended, and a final updated version of the framework (Pedagogical Scenarios) will be presented in M24 (D2.4 Pedagogical inquiry scenarios for re-use of inquiry activities).

Outline of initial pedagogical scenarios:

- Scenario 1: Introduction to the inquiry model of the Ark of Inquiry project
- Scenario 2: Changing the Proficiency Level
- Scenario 3: Adding Inquiry Phases
- Scenario 4: Improving Gender Inclusion
- Scenario 5: Overcoming Language Barriers

The pedagogical scenarios described in this document are generic, meaning that each scenario can be implemented in relation to any inquiry activity inside and outside of Ark of Inquiry where the scenario applies to. There are three advantages of using generic scenarios instead of specific (activity level) scenarios. Firstly, generic scenarios are less resource intensive compared to specific scenarios; it is clear that the project does not have resources to provide specific scenarios for individual activities. However, the latter can be achieved via another mechanism, namely asking teachers to share their amended activity plans for activities that they select and use in their classrooms. Secondly, generic scenarios allow flexible and widespread use of the existing activities in Ark of Inquiry, making it easier to adapt individual activities into various classrooms (e.g., match the level of challenge offered by the inquiry activity to the pupil's ability), irrespective of different age and skill levels, formal/informal learning situations, and different country contexts. Thirdly, generic scenarios put the teacher into the role of an active designer of learning situations, instead of being a passive content consumer. The role of a designer will endorse the feeling of teachers' ownership, autonomy and commitment to the inquiry activities (Rutten, 2014), which can be considered as important for achieving large-scale and sustainable uptake of Ark of Inquiry across the schools in Europe.

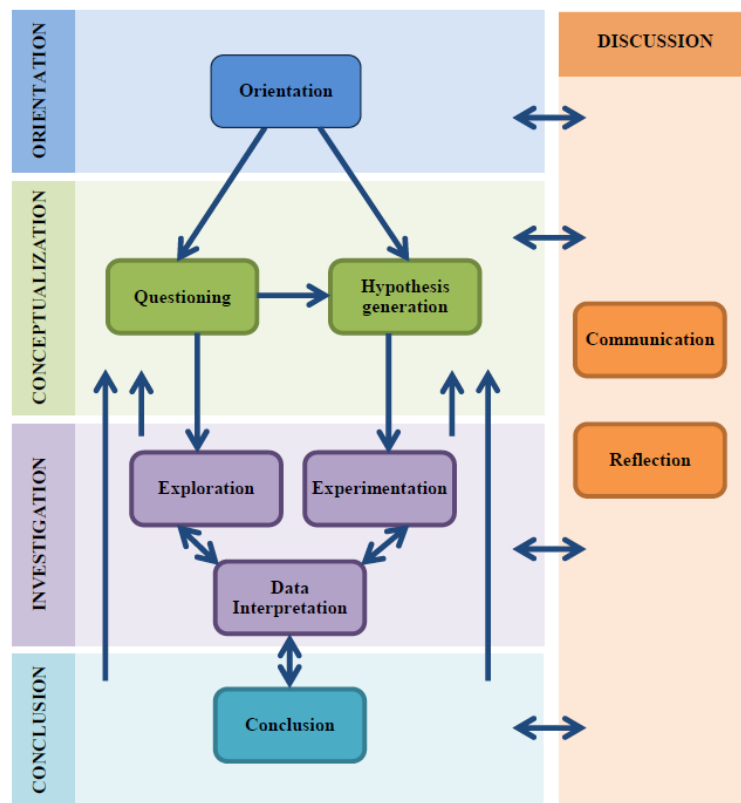
In summary, the Pedagogical Scenarios are designed to enhance the uptake and use of inquiry activities across schools in Europe in the context of the Ark of Inquiry project. The scenarios in this deliverable will also be a component of the Ark of Inquiry support system (D1.4 Specification of support systems in Ark of Inquiry) and can be used by teachers to adapt and/or amend activities when they work with the activities in the Ark of Inquiry during the teacher training (WP4) first, but also on their own later.



## 2. Pedagogical Scenarios

### Scenario 1: Introduction to the inquiry model of the Ark of Inquiry project

Inquiry learning is a process that is often complicated for learners (e.g., Veermans, van Joolingen & de Jong, 2006), and dividing the process into phases can make it more easily explained and understood, especially when learners are not very proficient yet.



**Figure 1.** Inquiry model by Pedaste et al. (2015)

The inquiry model in the Ark of Inquiry is based on the model by Pedaste et al. (2015; Figure 1) and consists of five distinct inquiry phases: Orientation, Conceptualization, Investigation, Conclusion, and Discussion.

- The Orientation phase starts with generating curiosity about the topic among the learners which leads to the problem statement.
- The Conceptualization phase includes both posing the questions and/or generating the hypotheses.
- The process of Investigation is divided into three sub-phases: Exploration, Experimentation and Data Interpretation. Exploration is a process of data generation taking into

consideration the research question. The process of designing and conducting an experiment in order to test the hypothesis is termed Experimentation. Data Interpretation is a process of making meaning of data compiled and synthesizing new knowledge.

- The aim of the fourth phase – Conclusion – is to draw conclusions based on the data.
- The last, Discussion phase, can be divided into two sub-phases: Communication as a process of presenting outcomes, collecting feedback, and discussion with others; and Reflection as a process of discussing the whole inquiry cycle. The Discussion can be fostered in all phases of inquiry cycle (Pedaste et al., 2015).

The idea behind the model and its adoption in the Ark of Inquiry is that inquiry activities consisting of all five inquiry phases are desirable, because they ensure that learners get a good and comprehensive learning experience in the process that a) resembles scientific inquiry, b) helps to improve their inquiry skills and proficiency (i.e. the ability to generate and evaluate scientific evidence and explanations), and c) promotes their understanding of the process of conducting science in a better and more responsible manner.

The phases of Orientation and Discussion are particularly important in the context of the Ark of Inquiry as they provide the connection between activities and the broader societal contexts and increase the learners' awareness and understanding of conducting 'real' science. A meaningful orientation phase can provide the learners with a context that gives relevance to the activity while activating their prior knowledge on the topic. The importance of the discussion phase is that it can make learners understand that what they have done, how they have done it and how they interpret its meaning is not a final product but an object for discourse and argumentation that initiates reflection and meaning making. This helps to convey the message that nowadays science is inherently a social act that is about collaboration and discourse.

In practice there is a variety of different inquiry models. A popular model is that of Bybee's 5E-model (Bybee et al., 2006), which consists of five inquiry phases: Engagement, Exploration, Explanation, Elaboration, and Evaluation. Another well-known model is that of White and Frederiksen (1998), which also emphasizes five inquiry phases but names them as Question, Predict, Experiment, Model, and Apply<sup>1</sup>. Differences between White and Frederiksen's and Bybee's models appear in the approach: the first two phases (Engagement and Exploration) in Bybee's model are describing the inductive approach (data-driven/empirical) whereas the two first stages of White and Frederiksen's model are concentrating on deductive approach (hypothesis/theory driven) (Pedaste et al., 2015).

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<sup>1</sup> The inquiry phase "Apply" is more future-oriented and not directly connected to inquiry-based learning. Therefore it will be left out of the inquiry cycle.

**Table 1.** Mapping Bybee’s and White and Frederiksen’s model onto Ark of Inquiry 5-phase model

<b>Inquiry phases in Ark of Inquiry 5-phase model</b>	<b>Inquiry phases in Bybee’s model</b>	<b>Inquiry phases in White and Frederiksen’s model</b>
Orientation	Engagement	-
Conceptualization	Engagement	Question and Predict
Investigation	Exploration	Experiment and Model
Conclusion	Explanation and Evaluation	Model
Discussion	Explanation and Elaboration	-

Although the models described above (Ark of Inquiry’s, Bybee’s and White and Frederiksen’s inquiry models) are distinct inquiry models, they exhibit a high degree of correspondence and similarity with each other in regard with their inquiry phases. Table 1 shows how Bybee’s and White and Frederiksen’s models can be mapped onto the Ark of Inquiry model in regard with the inquiry phases (Table 1). As can be seen from the table, the inquiry phases described in the Ark of Inquiry model mostly coincide with the phases in Bybee’s model, with the main differences lying upon the names of phases and some phases in one being a combination of two phases in the other. And the other way around White and Frederiksen’s model consists of three phases which can be directly mapped onto three phases of inquiry process as described in the framework of Ark of Inquiry (Conceptualization, Investigation, and Conclusion), but is lacking the Orientation and Discussion phases.

These mapping examples show that for someone who is familiar with an inquiry model other than that used in the framework of the Ark of Inquiry Project, using the Ark of Inquiry activities should not pose any obstacle, as inquiry phases of different inquiry models seem to be largely overlapping and overall seem to be looking in the same theoretical direction.

The next section shows a more practical example of an inquiry activity and mappings between different inquiry models within the activity. The inquiry activity “Hanging with friends” (<http://wise.berkeley.edu/previewproject.html?projectId=4>) (Figure 2) aims at learners integrating verbal, animated, and algebraic representations of velocity, enabling learners to interact with three dynamic models and guide them to apply the knowledge to solve the real-world problem. The activity has five inquiry phases as described in the Ark of Inquiry inquiry model. The mapping of the models is presented below.

## City Map

The stars (★) on the City Map below show the location of the friends from the text message conversation. Use the City Map to figure out the distance and direction each friend needs to travel to the Movie Theater (Cinema).

**Fill in Columns A and B in Table A in the "Hanging With Friends" Worksheet with the *distance* and *direction* each friend needs to travel to the Movie Theater..**

Remember:

- Vijay is across the street from the City Library.
- Antonio is at the Police Station.
- Isabel is at the Lake Park.
- Shanice is at City Middle School.



**Figure 2.** *Hanging with friends inquiry activity*

- The Orientation phase starts with providing pupils with a short story to trigger their interest on the topic. The Orientation phase here is connected to the Engagement phase in Bybee's model. However, this phase is not included in White and Frederiksen's model.
- The next phase (Conceptualization) continues with posing questions. In the current example the sample questions are provided (e.g., what type of transportation do you think each friend should use if they need to arrive at the theatre in exactly 10 minutes?). White and Frederiksen divide this phase into Question and Predict providing opportunity to question and hypothesize, while in Bybee's model this phase maps onto the Engagement phase.
- The third phase (Investigation) includes the conduction of an experiment; in the current example learners are expected to use dynamic models in order to solve real-life problems. The Investigation phase is termed Exploration in Bybee's model, while White and Frederiksen divide this phase into two phases: Experiment and Model.

- The Conclusion phase in the current example aims for the interpretation and evaluation of the results – Explanation and Evaluation phases in Bybee’s model. In White and Frederiksen’s model the corresponding phase is termed Model.
- The Discussion phase in the current example includes the reflection process. In White and Frederiksen’s model the Discussion phase is basically missing while in Bybee’s model it is divided into Explanation and Elaboration phases.

The example above illustrates how other inquiry models can be mapped onto the 5-phase Ark of Inquiry inquiry model. The example suggests that in the activities that are in line with the Ark of Inquiry inquiry model one can still detect the corresponding parts and similarities with other inquiry models and their phases can still be mapped onto those of other inquiry models. Thus, even if teachers are familiar with another inquiry model they can still use the activities that follow the Ark of Inquiry model in their structure. In a similar fashion, an activity based on another inquiry model can still be considered and used in the Ark of Inquiry framework.

Although inquiry activities that cover all five inquiry phases are the optimum choice, after a review of existing inquiry activities in the initial work in the context of Deliverable D2.3, it was noticed that it is quite common for them to be lacking one or more inquiry phases. In other words, an activity that consists of all five inquiry phases is not always a given. However, in many cases inquiry activities that miss one or more phases can still (and should) be considered for use. In the following scenarios it will be shown that the difficulty level of activities can be modified and amended by adding structure and guidance to the activity (Scenario 2) and that underdeveloped or missing inquiry phases can be amended or added (Scenario 3) in order to strengthen the overall educational value of an activity.

## Scenario 2: Changing the Proficiency Level

It is important to match a learner's level of inquiry proficiency (i.e. her or his inquiry capacity and skills) to a suitably challenging inquiry activity. The degree of challenge presented by an inquiry activity determines the proficiency level of the inquiry activity. Based on the Inquiry Proficiency Framework developed in Work Package 1, inquiry activities can be divided into the following three proficiency levels: A-Novice, B-Basic, and C-Advanced.

- At the lowest, Novice level (A) activities aim mainly at engaging learners in and introducing them to structured inquiry activities.
- At the Basic level (B) the inquiry activities become semi-structured and guide learners towards independency related to knowing how to inquire and reflection on and discussion related to the activity.
- At the Advanced level (C) learners can already shape their own inquiry activities and reflect and discuss outcomes in collaboration with diverse stakeholders.

Many inquiry activities have the potential to be used at different inquiry proficiency levels depending on the structure and the amount of support that they provide the learners with during the inquiry process. The following two examples are designed to illustrate this scenario and highlight ways to change the proficiency level of inquiry activities, in order to fit them to the needs of individual classrooms and pupils. The first example to show how changing proficiency levels might work is based on a computer-based simulation that models the functioning of electric circuits and its nine additional worksheets. The example first describes an A level activity, very structured and with a high level of support, which turns to a B level activity by reducing the structure and guidance provided in the worksheets. The second example is based on a database that provides real data about fish caught in a fish trap over a period of many years. Differently than the first example, the second one will first provide a C level activity around this resource which then turns into a B level activity by providing more structure and guidance, and then to an A level activity by providing even more guidance.

## Example 1: Electricity Lab

### Original A-level activity

Title: Electricity Lab

Domain: Physics

Topic: Electricity, Simple electric circuit

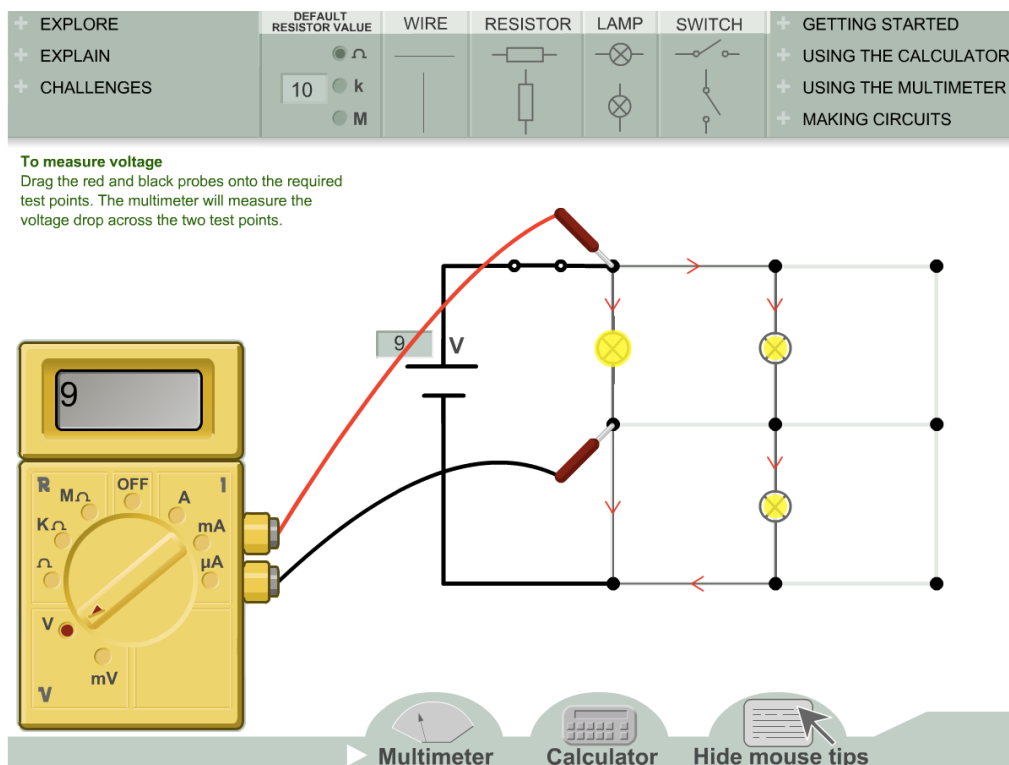
Language: Finnish, English

Language dependency: High

Typical age range: 11–15

Inquiry proficiency level: Novice (A)

Inquiry phases covered: Conceptualization, Investigation, Conclusion



**Figure 3.** *The Electricity Lab used in the initial activity. The Lab is an easy-to-use simulation for constructing simple DC circuits, observing circuit functionalities, and conducting electrical measurement. Every operation is conducted by dragging and clicking with the mouse.*

In this inquiry activity learners are guided to explore the basic principles of electric circuits by using a computer-based simulation that models the functioning of electric circuits (Figure 3). The objective of the activity is to discover the basic principles behind the functioning of the electric circuits on a qualitative (relationship between the number of bulbs, the circuit configuration, and the bulb brightness) and quantitative (relationship between the number of

circuit components, the circuit configuration, and the voltage across circuit components) level<sup>2</sup>.

This is in its original form an A-level activity, because learners' inquiry process is guided carefully by a structured series of nine instructional worksheets that provide a high level of support. The worksheets are designed to activate learners' prior conceptions on electricity, confront common misconceptions identified by previous research and correct these misconceptions by gradually introducing the scientific model. The worksheets instruct learners to construct various circuits and conduct various electrical measurements with the simulation. The worksheets also contain instructional scaffolds that ask the learners to investigate and infer how the changes and differences in circuit configurations affected circuit behaviour. The worksheets gradually become more difficult and divide the inquiry process into small units, creating many small inquiry cycles that each address a specific part of the domain (e.g., open-closed circuits, single-multiple components, series-parallel circuits), and in that sense they can also serve as a way to build in model progression (White & Frederiksen, 1990) in a domain.

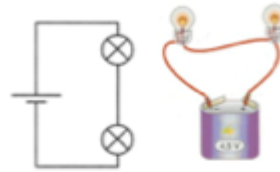
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<sup>2</sup>The effectiveness of the Electricity Lab activity, both in terms of learning outcomes and engagement, and across various grade levels (from 5th to 8th grade; 10–15 years), has been verified in several scientific studies (Jaakkola & Nurmi, 2008; Jaakkola, Nurmi & Veermans, 2011; Jaakkola & Veermans, 2014; Tapola, Veermans & Niemivirta, 2013). It has been found that this type of activity helps pupils to learn the basic principles of electric circuits and overcome many of their misconceptions. Although using real equipment can complete this type of activity, the use of a computer simulation (or a combination of real equipment and a simulation; Jaakkola & Nurmi, 2008; Zacharia, 2007) is recommended, because the use of the simulation is likely to result in better understanding of the circuits than the use of real equipment alone. The activity has also been rated as highly engaging by both genders.



- a) **WITHOUT COMPUTER** Predict what happens to the brightness of the bulbs if one bulb is added to the previous circuit as illustrated in the nearby pictures (2 bulbs in series). Check if you agree

- There is no change in the brightness of the bulbs
- The bulbs become brighter
- The bulbs become dimmer
- The upper bulb is brighter than the lower bulb

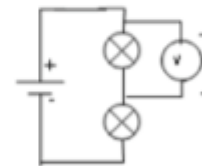


- b) **WITH COMPUTER** Test your prediction by constructing the circuit with the computer. Remember to push the switch down when you are ready. What do you notice (check if you agree)?

- There is no change in the brightness of the bulbs
- The bulbs become brighter
- The bulbs become dimmer
- The upper bulb is brighter than the lower bulb

- c) **WITH COMPUTER** Measure the voltage of the upper bulb of the circuit with the voltage meter as instructed in the nearby picture

The voltage of the upper bulb is \_\_\_\_\_ volts.



- d) **WITH COMPUTER** Now, measure the voltage of the lower bulb. The voltage of the lower bulb is \_\_\_\_\_ volts.

- e) What can you say about the voltages of the two bulbs?

- The voltages are the same
- The voltages are different

What can be said about the voltages of the lamps in comparison to the voltage of the battery in a two-bulb series circuit (check if you agree)?

- The voltage of a single bulb and the voltage of the battery are the same
- The voltage of a single bulb is half of the voltage of the battery
- The voltage of the battery is divided equally between both bulbs
- The total voltage of two bulbs is equal to the voltage of the battery
- The total voltage of two bulbs is half of the voltage of the battery
- The total voltage of two bulbs is two times the voltage of the battery

**Figure 4.** A worksheet example from the original A-level activity

Figure 4 shows an example of one worksheet from the initial (A-level) activity. In the example, the learners are asked to build and investigate a two bulb series circuit (prior to this worksheet, the learners have investigated a single bulb circuit and learned the concept of closed circuit; after this worksheet the learners will continue investigating the properties of series circuits by constructing a three bulb series circuit; after that, they switch to parallel circuits). The worksheet starts with a conceptualization/hypothesis generation phase, where the learners are asked to hypothesize the circuit behaviour prior to using the simulation. In

the second step comes the actual investigation phase, where the learners are guided to set up the circuit, investigate the circuit behaviour (e.g., monitor changes in bulb brightness) and conduct electrical measurements with the voltmeter. The activity ends with a pre-formatted conclusion phase in which the learner is asked to induce/extract principles from the investigation phase.

### **Modified B-level activity**

Title: Electricity Lab

Domain: Physics

Topic: Electricity, Simple electric circuit

Language: Finnish, English

Language dependency: **Medium**

Typical age range: 11–15

Inquiry proficiency level: **Basic (B)**

Inquiry phases covered: Conceptualization, Investigation, Conclusion

Using the below 4-step example, it is relatively easy to change the proficiency level of the original activity to B-level by reducing (or stripping off) the structure and guidance that the worksheets provide (it should be noted that this change will also reduce the language dependency of the activity; see Scenario 5).


1. Use one bulb and wire(s) to investigate under which condition the bulb does and does not light. When you succeed to light the bulb, you have successfully created a closed circuit. Always measure the voltage across the bulb after each configuration change and compare the reading to the battery voltage. Also, keep an eye on the bulb brightness after each configuration change. Take notes so that you can reflect on the findings later.
2. Add a second bulb to the circuit and make a configuration where both bulbs will first turn on, and both will turn off when a wire is removed. Once you succeed, you have created a two bulb series circuit.

Based on your experimentation so far, what kind of conclusions (e.g., related to bulb brightness and voltages) can you draw about the underlying circuit laws and principles?
3. Change the previous configuration so that when you again remove one wire, only one of the bulbs will turn off (the other will remain on). Once you succeed, you have created a two bulb parallel circuit.

Based on your recent experimentation, what kind of conclusions can you draw now about the underlying circuit laws and principles (be open-minded and prepared to change/elaborate on your conception from the earlier phases)?
4. Design a circuit with three bulbs where bulb brightness is the following:  $A > B = C$ . Are there different ways you can configure the circuit that confirms the criteria? Draw the circuits.

Considering all the above experiments that you have conducted, what kind of summary and final conclusions can you draw about the underlying circuit laws and principles?

Apart from leaving more initiative to the learners, these kinds of tasks also bring some advantages for creating discussion opportunities for learners, as the more open-ended nature



of the tasks also means that learners can create alternative solutions to the same design problem, which in turn can be the topic for discussion. (e.g., different solutions to a problem, discuss the alternatives, and discuss what are the similarities and differences between the different solutions).

This first example showed how an A level activity that was initially very structured and very explicit in its guidance towards the learners can be relatively easily changed into a B level activity by removing explicit guidance and some of the structure. As a side effect it was shown that doing so also creates natural opportunities for discussion, one of the important aspects in the Ark of Inquiry's model. The second example will approach changing the proficiency from the other end. It will start from a C level activity and change this activity first to a B level and subsequently to an A level activity by adding more structure and guidance. The example is based on a database that provides real data about fish caught in a fish trap over a period of many years.

## Example 2: The Waddenzee Fish Monitor

In 1959 the Zoology Station (nowadays NIOZ) laid down the foundation for the fish monitor in the Waddenzee. Until 1974 there were different locations and different fish traps, but from 1974 onwards there has been only one fish trap on a single location (the fish trap at the Stuifdijk, in the Marsdiep near the island of Texel, the Netherlands).

The regular season for fishing and monitoring starts every year in March or April and continues until October. In the winter the fish trap is removed from the water because icing might damage the net. During the monitoring period the fish trap is emptied every day and the fish are transferred to the NIOZ laboratory.

In the laboratory, the fish are identified by their species and measured. All information is added into a database on a yearly basis for research purposes. The fish monitor website (<http://www.waddenzeevismonitor.nl/grafiek-vangstgegevens.html>) provides some of this data to the general public (Figure 5). It provides two views on a large number of species, one that shows the average amount caught per day by year, and one that shows the average amount of fish per month over all years. The data can be used to identify patterns for many species. The fish monitor shows the data but does not answer questions related to the origins of these patterns.

### Eigen grafiek samenstellen van vangstgegevens

Op deze pagina kunt u grafieken samenstellen met de gegevens uit de database van deze vismonitor. U kunt maximaal drie soorten kiezen om te vergelijken. Dit wordt naar keus getoond in een verzamelgrafiek of apart. Geef aan binnen welke tijdsspanne u de gegevens zoekt. Kies voor een weergave per maand of per jaar. De data worden weergegeven als gemiddelde per vangdag.

Kies eerste soort

Kies tweede soort

Kies derde soort

Manier van tonen

Kies de periode

Vanaf  t/m

**Figure 5.** The Fish Monitor, a database of fish caught in a hoop net at fixed spot in the Dutch part of the North Sea over a period of many years

### Initial C-level activity

Title: Fish Monitor

Domain: Biology

Topic: Sea life, Fish population development

Languages: Dutch, English

Language dependency: Low

Typical Age Range: 15–18

Inquiry Proficiency Level: Advanced (C)

Inquiry Phases covered: Conceptualization, Investigation, Conclusion

In this activity you can place yourself in the role of one of these researchers and use the data that is provided through the fish monitor to design your own research project and research questions that investigate changes in the ecological system of the Waddenzee area and try to answer these questions with the data from the fish monitor. You can start by orienting yourself (get acquainted with the data, search and read background information) on the types of questions that can be answered with this data (types of species and their population development over time, habitation changes, etc.), formulate your own research questions (and hypotheses), investigate, draw a conclusion, and present and discuss your outcomes (for instance, to the developers of the fish monitor).

As one can see, the example above has very little structure and guidance and is very openly formulated. It does have reference to the inquiry phases, but only as a general guideline, not very detailed. This could work for proficient learners (hence the C or advanced level rating), but other learners would need more structure and support in the process to do some inquiry with the fish monitor. In the next section more structure and support is added in order to turn the activity into a B (Basic) level.

### **Modified B-level activity**

Title: Fish Monitor

Domain: Biology

Topic: Sea life: Fish population development

Languages: Dutch, English

Language dependency: **Medium**

Typical Age Range: **12–16**

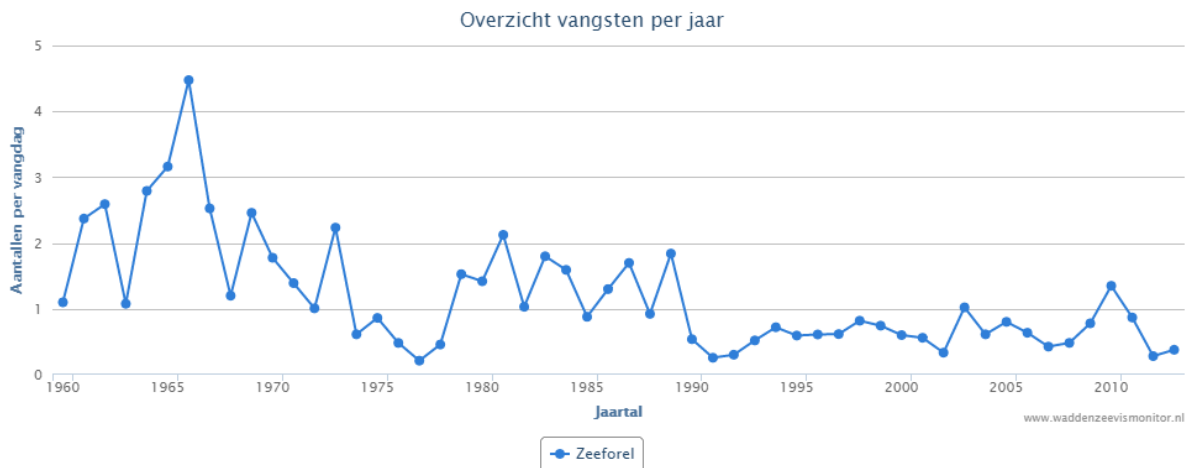
Inquiry Proficiency Level: **Basic (B)**

Inquiry Phases covered: **Orientation**, Conceptualization, Investigation, Conclusion, and **Discussion**

**Orientation:** Go to your local fish market (or store) and find out what kind of local sea fish they are selling (if your country has no sea, you can focus on sea fish in general). Use these as a first basis to explore the fish monitor. Which of the fish from your local seas are also caught in the Waddenzee? What could it mean if a local fish is or is not caught in the Waddenzee?

**Conceptualization:** As we have seen in the orientation, not all fish are living in all places. The place where certain species live is also referred to as its habitat. A habitat is made up of physical factors like water quality, range of temperature and availability of light as well as biotic factors such as the availability of food and the presence of predators. Because of the more or less specific demands for a species to the habitat (e.g., amount of food available, temperature of the water), certain areas might be suitable for some species rather than for others, and this might also change over time.

In the introduction it was mentioned that the fish monitor provides two views on a large number of fish species, one that shows the average amount caught per day by year, and one that shows the average amount of fish per month over all years. Which view would be more suitable to determine if the Waddenzee as a habitat has changed for some or all of the species? Would you think that changes will equally affect all species? The research question related to this last question that we will try to answer in this activity is 'If we rank each species based on the amounts of fish caught in a year, is this ranking stable over the years or not?'



**Figure 6.** Graph Produced from the Fish Monitor database

**Investigation:** If you don't have enough overlap with your local fish or if you do not find some of the fish types, you can pick some more species from the list until you have 10 (e.g., *zeebaars*, *ansjovis*). Select each of these species in the monitor (where it says "Kies eerste soort") and look at the graphs for yearly catches. In order to make the rankings, we will look at several years with equal time intervals between the years (e.g., 1980, 1988, 1996, 2004, and 2012). Reflection question: Why are we not looking at 1972, 1964 and 1956 (in other words the time before 1974)? Record the amounts for each species (hover your mouse over the point in the graph to get the exact number), and make a table that has species in the rows, years in the columns and amounts in the cells (Figure 6). Now you could convert this table into a ranking table (most caught in a year = 1, least caught = 10).

**Conclusion:** Is the ranking of the species stable over the years that you looked at (If so, what do you think that means? If not, what does that mean?)? Is the ranking telling the full story of what you see when you look at the graphs and the table that you made (If not, what else have you noticed?)? Write down your observations and conclusions in such a way that they are easily understood by someone who has not seen all the information that you have been looking at during your investigation.

**Discussion:**

What do you think could be reasons behind some of the conclusions that you have been writing in the previous phase (e.g., think back at the short description of habitat in the conceptualization phase, and try to connect some of the elements from there to your findings)? Did you notice any other things during this activity with the fish monitor that you think are worthwhile discussing with your classmates? Discuss with your classmates what they think.

The **example** above already has more structure and support and clearly indicates all phases, but is still not so detailed within the phases. This could work for basic level learners that have some prior inquiry experiences and know about the topic, but novices might still need more support in the process to do some inquiry with the fish monitor. In the next section we add further support within the phases in order to turn the activity into an A (Novice) level activity.

**Modified A-level activity**

Title: Fish Monitor

Domain: Biology

Topic: Sea life: Fish population development

Languages: Dutch, English

Language dependency: **High**

Typical Age Range: **10–13**

Inquiry Proficiency Level: **Novice (A)**

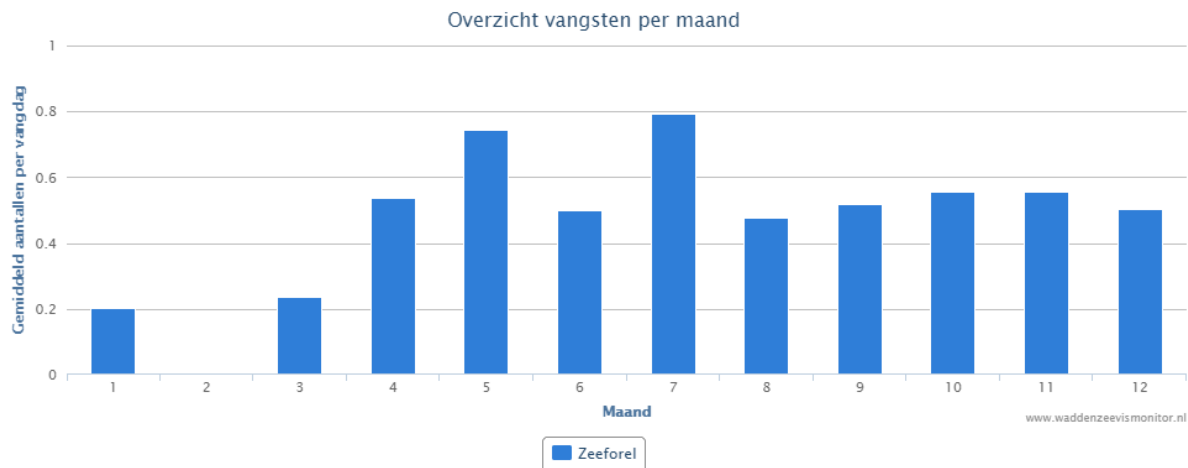
Inquiry Phases covered: Orientation, Conceptualization, Investigation, Conclusion, and Discussion

**Orientation:** Go to your local fish market (or store) and find out what kind of local sea fish they are selling (if your country has no sea, you can focus on sea fish in general). Use these as a first basis to explore the fish monitor. Which of the fish from your local seas are also caught in the Waddenzee? What could it mean if a local fish is or is not caught in the Waddenzee?

**Conceptualization:** As we have seen in the orientation, not all fish are living in all places. The place where certain species live is also referred to as its habitat. A habitat is made up of physical factors like water quality, range of temperature and availability of light as well as biotic factors such as the availability of food and the presence of predators. Because of the more or less specific demands for a species to the habitat (e.g., amount of food available, temperature of the water), certain areas might be suitable for a species whole year around or only part of the year. In this activity we are going to find out how we can recognize and identify these two types of species from real life data from the fish monitor.

In the introduction it was mentioned that the fish monitor provides two views on a large number of fish species, one that shows the average amount caught per day by year, and one that shows the average amount of fish per month over all years. Which view would be more

suitable to determine whether a fish species lives in the Waddenzee whole year around or only part of the year? Do you already have an idea how you could recognize these two types of fish from that view?



**Figure 7.** Graph produced from the Fish Monitor database


**Investigation:** If you don't have enough overlap with your local fish or if you do not find some of the fish types, you can pick some species from the list (some examples for this investigation are *zeeforel*, *kabeljauw*, *zeebaars*, *puitaal*, *spiering*, *makreel*, *ansjovis*). Select each of these species in the monitor (where it says “Kies eerste soort”) and look at the bar charts for monthly catches (Figure 7).

**Conclusion:** Can you see the difference between whole year around and part of the year species? Make a list of species that you think are living in the Waddenzee all year around, and of species that only live there part of the year. Did you also come across species that fit neither in the whole year around nor the only during a certain period category (if not, try some more species from the list)?

**Discussion:** What could be the reasons for fish living in the Waddenzee all year around or only for some part of the year (hint: look at the conceptualization text)? What could be a categorization for the fish (hint: look at the other graph to see in how many different years they have been caught in the fish trap)? Did you notice any other things during this activity with the fish monitor that you think are worthwhile discussing with your classmates? Discuss with your classmates what they think.

This example showed how a real-life data source could be used to provide different proficiency level activities for learners. It first showed how an initially very open-ended C level activity could be changed into a B level activity by adding more structure and guidance to the inquiry process and subsequently how an A level activity could be created by adding more explicit guidance to the inquiry process.





Together the two examples illustrate how changing proficiency is possible in both directions (towards more proficient or towards less proficient) through adding or removing structure and guidance. Being able to do and doing so allows more wide and more flexible use of activities through adjustments of activities to the present needs.

## Scenario 3: Adding Inquiry Phases

Scenario 1 provided a detailed description of the Ark of Inquiry inquiry model and the (five) inquiry phases of that model. Activities covering multiple inquiry phases are highly recommended and desired, because such activities are more likely to be engaging and productive (see Scenario 1 for more details and Deliverable D2.1 for the rationale). However, as the Ark of Inquiry project is building on existing materials, it cannot be assumed that all activities follow the pedagogical framework that was specified in D1.1. As such there might be a need to add a phase to an activity. While one could see the lack of inquiry phases as problematic for the activities, this is not necessarily always the case. Rutten (2014), for instance, found that teachers sometimes felt restricted by structured resources resulting in less inquiry and less student-centred activities in the classroom than without using the resource. At the same time he found that in classes where the teacher scored higher on a measure assessing resemblance between the lesson and the inquiry cycle, learners reported a higher level of understanding. This highlights two important aspects about the use of resources by teachers, namely that teacher ownership is important, and that a prerequisite for this successful ownership is that teachers can amend inquiry activities. Apart from the fact that adding the phase leads to more complete activities, doing so also adds to teachers' feeling of ownership of the activities. The following two examples will highlight how to add phases to an existing inquiry activity.

## Example 1: the Electricity Lab

Title: Electricity Lab

Domain: Physics

Topic: Electricity, Simple electric circuit

Language: Finnish, English

Language dependency: High

Typical age range: 11–15

Inquiry proficiency level: Novice (A)

Inquiry phases covered: Conceptualization, Investigation, Conclusion

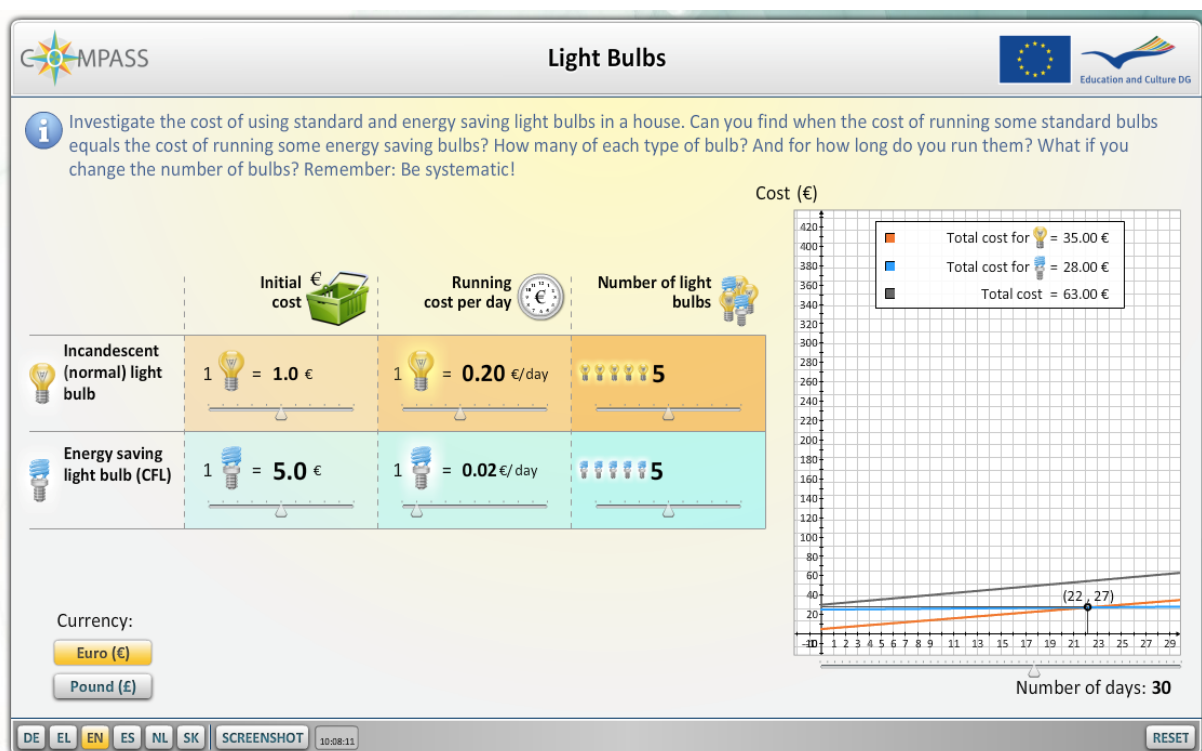
This is the same Electricity Lab inquiry activity that was already introduced in the "Changing the Proficiency Level" scenario above (see Figure 3). In summary, the Electricity Lab is a highly structured inquiry activity that aims to teach the learners about electrical circuits and provide hands-on practice for them to investigate, create and measure electric circuits. The activity consists of three inquiry phases, which are repeated in each worksheet (in which sense the activity consists of several mini inquiry cycles). Each worksheet starts with a conceptualization/hypothesis generation phase, where the learners are asked to hypothesize the circuit behaviour prior to using the simulation. In the second step comes the actual investigation phase, where the learners are guided to set up the circuit, investigate the circuit behaviour (e.g., monitor changes in bulb brightness) and conduct electrical measurements with the voltmeter. The activity ends with a pre-formatted conclusion phase in which the learner is asked to induce/extract principles from the investigation phase. Although the activity has been found as highly effective, it can be improved further, because it is incomplete from the point of view of the Ark of Inquiry framework in the sense that it is missing two of the inquiry phases, namely orientation and discussion<sup>3</sup>. These two phases have particularly important roles in the context of the Ark of Inquiry as they provide the connection between activities and the broader societal contexts for which we aim to educate our learners. A meaningful orientation phase can provide the learners with a context that gives relevance to the activity while activating their prior knowledge on the topic. The importance of the discussion phase is that it can make learners understand that what they have done, how they have done it and how they interpret its meaning is not a final product but an object for

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<sup>3</sup>The original activity included even the orientation and discussion phases, but in the context of Ark of Inquiry these phases can be considered weak and/or incomplete. In the original context the orientation phase (that included a general introduction to the topic, worksheets, and the simulation) was given in an oral format (and there is no reason why this could not be provided by a teacher). What should be noted, however, is that even though it could qualify as orientation, it would not qualify as orientation that provided a meaningful context to the pupils in a way that it could be expected to raise pupils' awareness of RRI. The discussion phase was not entirely absent in the reference activity either, because the pupils were working in pairs. However, the discussion within a pair was rather implicit and by no means guaranteed to be fruitful (some of the pairs actually showed very little sign of discussion or even collaboration). It would therefore be advisable to strengthen the discussion by building in something in the activity that makes discussion and the role of discussion in science studies more explicit to the learners.

discourse and argumentation that initiates reflection and meaning making. This helps to convey the message that nowadays science is inherently a social act that is about collaboration and discourse.

In the case of the Electricity Lab activity, depending on the age of learners and their experience with electric circuits, it might be necessary to build an orientation phase that provides a general introduction (the orientation phase) to the topic of electricity and electric circuits. This can be accomplished, for instance, by asking learners to watch a short introductory video (e.g., <https://www.youtube.com/watch?v=EJeAuQ7pkpc>) or tutorial (<http://scienceofeverydaylife.discoveryeducation.com/views/other.cfm?guidAssetId=D1507F6E-09C3-4E7B-B1E9-16708E402009>) on the topic and/or read a more detailed description (<http://www.explainthatstuff.com/electricity.html>). As discussed above, it is especially important to connect the activity to a wider societal context and the orientation phase is a good place to make the connection. Compass project, for instance, provides several (extensive) assignments where pupils can learn about the differences between traditional and energy-saving light bulbs (as well as the pros and cons of each) and investigate whether and how much energy can be saved by using energy-saving lamps ([http://www.compass-project.eu/resources\\_detail.php?UG\\_hodnota\\_id=4](http://www.compass-project.eu/resources_detail.php?UG_hodnota_id=4); Figure 8). Such orientation can make the whole activity much more meaningful for the learners.



**Figure 8.** A tool for calculating the costs of traditional vs. energy-saving light bulbs

In the discussion phase the outcomes of the activity could be expanded to real-life situations and re-linked to the orientation phase. Learners could, for instance, be asked to reflect on and discuss the differences of series and parallel circuits for energy use, susceptibility to

malfunctions in a system (e.g., too many appliances on one power supply) and/or identify examples of such systems in and around their school and home environments, and discuss and examine why they are examples of the one or the other (e.g., why the heating element of a hairdryer should not remain working if the blower function breaks down).

## Example 2: Our Acidifying Ocean

Title: Our Acidifying Ocean

Domain: Biology

Topic: ocean acidification process

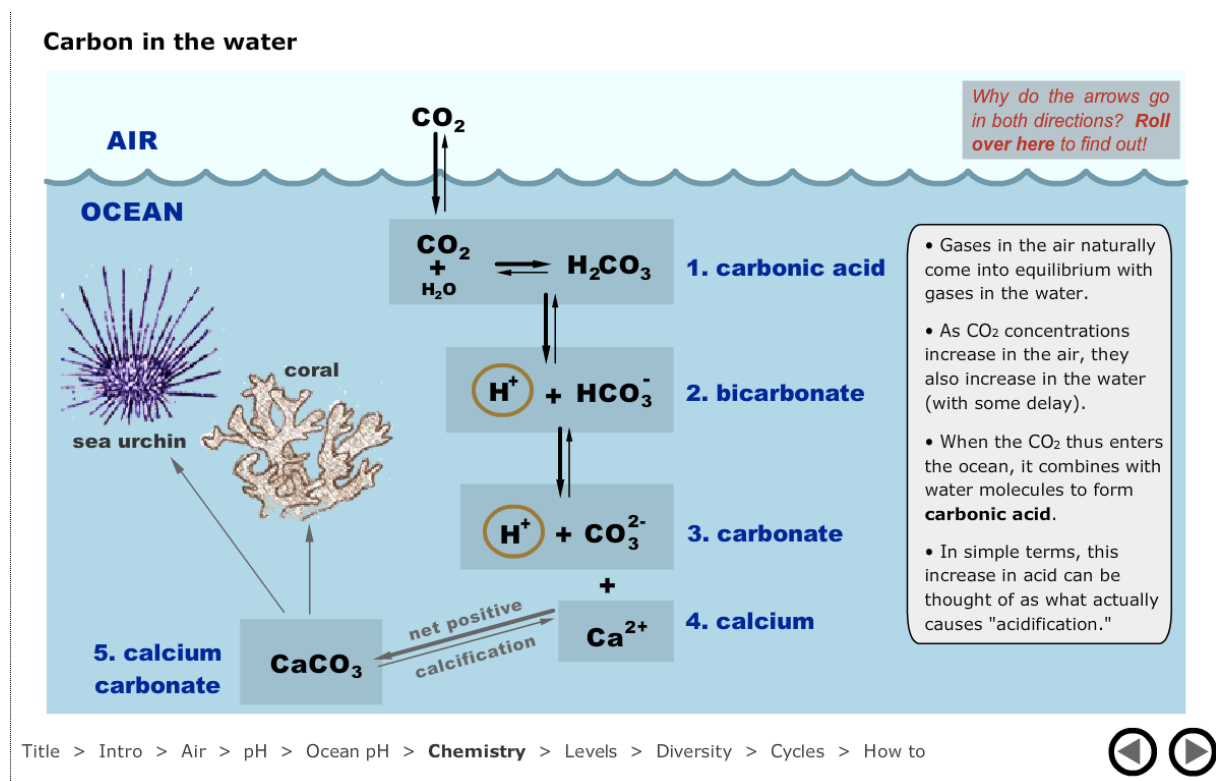
Languages: English, French, German, Spanish, Portuguese

Language dependency: High

Typical Age Range: 12–18

Inquiry Proficiency Level: Basic

Inquiry Phases covered: Conceptualization, Investigation, Conclusion



**Figure 9.** *Our Acidifying Ocean* is a virtual lab about the chemistry of ocean acidification and its impacts on sea urchin larvae

The following example will describe another case of how to strengthen an activity by borrowing phases from an existing material. The *Our Acidifying Ocean* (see Figure 9; <http://i2i.stanford.edu/AcidOcean/AcidOcean.htm>) is a virtual lab about the chemistry of ocean acidification and its impacts on sea urchin larvae (sea urchin – small, spiny, globular animals, with their close kin, such as sand dollars, constitute the class of Echinoidea of the echinoderm phylum; larva/plural larvae – a distinct juvenile form many animals undergo before metamorphosis into adults: e.g., caterpillars and butterflies).

The lab provides the learners with interactive models, a virtual lab bench, and a microscope measurement tool. The lab first presents some theoretical information, and then it continues

with a virtual Lab where the user can examine the effects of acidified seawater on sea urchin larval growth. The third part gives the users the opportunity to conduct their own measurements.

A major goal of the activity is to raise the awareness of the learners in regard with the impacts of ocean acidification through inquiry learning. In this activity learners are asked to collect the data, conduct the measurements, interpret the data, reach conclusions, and gain a good understanding of how the balance of nature can be disrupted by human actions.

The activity covers three of the five inquiry phases (conceptualization, investigation, and conclusion) and the proficiency level of all the phases covered can be regarded as basic because the environment is structured with fixed activities, the course of which cannot change, and guidance is provided to the users through each phase.

The first part of the lab provides some background information on the topic of the lab (chemistry of the phenomenon of acidification, a few greenhouse gas emission scenarios, their effects on coral calcification, and finally, the life cycle of echinoderm; echinoderms are a phylum of marine animals; the adults are recognizable by their (usually five-point) radial symmetry, and they include such well-known animals as starfish, sea urchins, sand dollars, and the sea lilies or "stone lilies").

However, the orientation phase of the activity is still incomplete; this is mainly because in the context of the Ark of Inquiry project it is envisioned that it is important in the orientation phase to provide the learners with a meaningful context that would make the connection with real-life dimensions of the problem more concrete and tangible. Thus, the orientation phase should be enriched or strengthened to be more beneficial in this aspect. This could be done either by choosing to create an entirely new orientation phase or by using already existing material as orientation on the topic. An example towards this aim is the following audio-virtual presentation (including both sound and slides) that a researcher from Gothenburg University has created for the "Our Acidifying Ocean" activity. The link is <http://voicethread.com/myvoice/#thread/1978581/10951973/16837821>. The presentation addresses many topics in its attempt to familiarize the learners with the topic of the "Our Acidifying Ocean" activity; it starts with the steps of the scientific method that the virtual laboratory involves and continues with the demonstration of the real laboratory facilities. Then, it moves to graphs with real statistical data on the impact of the phenomenon. It elaborates more on the broader dimensions of the problem in regard with its economic impact on food, agronomy and environment. The last part particularly aims to raise the awareness of the societal responsibility for scientists, politics, economists and citizens. Thus, learners are able to make the connection of a purely biological phenomenon with its harmful effects on the environment, economy and society. Learners are also provided with suggestions on how to act in order to reverse the situation and what is the merit of responsibility for each part in a society. This element is valuable in the context of the Ark of Inquiry project as one of the aims of the project is to increase pupils' awareness and understanding of conducting 'real'

science and prepare them to participate in different roles in the European research and innovation process.

Given that the original activity misses the discussion phase, it is possible that a few of the issues addressed in the orientation phase (the virtual and audio presentation mentioned above) can be brought up in the discussion and reconsidered; learners could get involved in group conversations or virtual presentations to share their views on the topic with their peers and the teacher. In this way it is not needed to create an entirely new discussion from the beginning, but with a relatively low threshold they could build upon something that already exists.

The above examples, along with the Fish Monitor example from the earlier Proficiency section, have demonstrated how an initially incomplete but potential activity can easily be amended and enriched by borrowing phases from an existing activity and developing/strengthening some of the phases on their own. In the examples this process results in more meaningful activities that both support the pupils in the process of learning about the domain and engage them in practices of inquiry not only directed at exploring the domain but also at communicating about the findings and connecting them to the wider societal contexts.



## Scenario 4: Empowering Girls in Science

One of the goals of the Ark of Inquiry project is to attract more women to science and science careers. Girls' negative views and low self-efficacy of STEM are often associated with characteristics of the learning environment that do not motivate and engage girls (e.g., Kim & Lim, 2013), or even lead them to underachieve (Spearman & Watt, 2013). Many programmes, including different types of tutoring or scaffolding systems, emphasize cognitive aspects of learning. However, in order to engage girls in STEM, motivational and emotional processes should be taken into consideration as well. There are two ways in which Ark of Inquiry activities do or can provide affordances in that direction and hence empower girls in science. The first is by providing active learner-centred learning environments that connect activities to environmental, societal and everyday-life contexts and the second by providing female role models and mentors in or around the activities.

### **Learner-centred learning environments in meaningful contexts**

It has been found that teaching/learning methods may play a role in increasing girls' interest in science. Inquiry-based learning that emphasizes student-centred learning in connection to environmental, societal and everyday-life contexts has provided positive results related to female pupils' interest in STEM. For instance, the outcomes of the MSOSW project (Middle Schoolers Out to Save the World) indicated that girls' attitudes towards science became generally more positive and even approximately equal to boys' attitudes during the project year. The MSOSW project included hands-on activities to guide pupils to solve real-world problems, combining both learner-centred learning environments and an everyday-life problem context. They used, for instance, energy monitoring equipment to monitor and audit power consumption by consumer electronic devices in their homes and communities. This way they tried to reduce the greenhouse gas emissions contributing to global warming. Pupils shared their results with other middle school pupils from across the U.S. (Knezek, Christensen, Tyler-Wood, & Periathiruvadi, 2013).

<b>Activity Sheet 1 (Mabrouk, 2006)</b>	
<p><b>Pam's creamy lip balm</b> One recipe makes enough to fill 30 lip balm containers.</p> <p><b>Ingredients</b> 18 g beeswax 43 g refined shea butter 65 g mango butter 11 g sweet almond oil 2 drops flavor oil per lip balm container</p> <p><b>Cautions</b> Hot oil can cause serious burn injuries if not handled properly. Do not put your hands in the oil or play with the oil solution.</p> <p><b>Instructions</b> 1. Put on a pair of gloves and safety glasses. If you have long hair, tie it back with a rubber band. 2. Select a flavor for your lip balm and place two drops in your lip balm container- 3. Working together as a team, we will measure each of the above fats into the Pyrex measuring cup and melt them on a hot plate while stirring continuously. 4. Remove the Pyrex measuring cup from the heat and add almond oil while stirring continuously. 5. I will carefully pour hot liquid lip balm into each container. Stir yours with a craft stick. If the lip balm in the Pyrex measuring cup solidifies, place the Pyrex measuring cup on the hot plate again to re-melt the lip balm. 6. Let lip balm in lip balm container cool and solidify. Cap container and label. Enjoy!</p>	<p><b>Equipment and materials</b> hot plate or stove top 30 containers for lip balm 450-mL capacity graduated Pyrex measuring cup metal spoon (for stirring) disposable plastic teaspoons disposable plastic eyedroppers disposable gloves (for sanitary reasons) wooden craft sticks (for mixing flavor in oil and lip balm oil) safety glasses</p> <p><b>Questions</b> 1. Beeswax, shea butter, and mango butter are all examples of fats. Sweet almond oil is an example of an oil. What characteristic do the beeswax, shea butter, and mango butter all have in common? What is different about sweet almond oil? What do you think might account for the physical differences between fats and oils? 2. What happened when we heated the fats? Did they change physically? Chemically? 3. Why do you think we didn't heat the sweet almond oil?</p>

**Figure 10.** Lip Balm: an example of an activity with an everyday (meaningful) life context

Another example of an active learner-centred learning environment with a clear connection to everyday life and environmental and societal contexts is that of Personal care chemistry project, in which pupils get to learn science hands-on by preparing their own lip balm and hand lotion (Mabrouk, 2006). The Personal care chemistry activities do not only provide scientific knowledge but also stimulate the development of good laboratory skills, and do not require specific prior knowledge. The lip balm and hand lotion projects can be part of chemistry (emulsions and solutions) and/or physical science lessons (examining the properties of matter). The projects strongly encourage discovery and exploration, since all the ingredients (for making lip balm and hand lotion) are safe, also when mixed in different combinations. For instance, experimenting with different flavours can be done by products found in baking section in supermarkets, such as cinnamon and peppermint; the ingredients required are also affordable. Furthermore, in this type of activities pupils have the opportunity to choose the ingredients for the products according to their own preferences and needs (e.g., select ingredients that they know and are comfortable using), while making sure to avoid those that can cause them any allergy or similar skin reactions. The fact that pupils can choose natural ingredients and avoid additives fosters a positive attitude towards environmental-

friendly practices while stressing the importance of those both on the ecological and societal level.

The lip balm project will take about 20 minutes, or if the pupils will measure all the ingredients by themselves, it takes about an hour. The hand lotion project will take about 40 minutes and the longer version 90 minutes. The teacher will introduce the workshop and will hand out pre-organized supply kits and activity sheets (see Figure 10), which also include some questions related to the learning content (Mabrouk, 2006). Apart from hands-on practice the activities provide easy affordances for creating discussions among pupils. For example, the pupils could be asked to calculate the sum cost of the ingredients they used and compare their ingredient list and price estimate with similar products available in shops as well discuss the differences and where these might originate from. This could encourage broader environmental and social discussions on industrialized products, their procedures, regulations and effects on the environment in relation to making their own products. In other words, apart from gaining scientific knowledge and skills, activities like these encourage critical thinking about the applicability of science in pupils' everyday lives. Because the core of the Ark of Inquiry revolves around inquiry learning, positive affordances of this type of learning/teaching method are a natural part of activities in the Ark of Inquiry project. Selecting and/or amending (see Scenario 3) activities with environmental, societal and/or everyday-life contexts would capitalize also on the affordances of these aspects for attracting girls to science and for the more general goals of the Ark of inquiry project.

### **Female role model**

The use of female mentors to guide girls' learning has also produced positive learning results. In the study by Tyler-Wood, Ellison, Lim, & Periathiruvadi (2012) female mentoring was combined with authentic learning experiences in a format of (environmental science) after school programme for 4<sup>th</sup> and 5<sup>th</sup> graders. The results indicated that the participants' knowledge of science improved significantly. The researchers also examined the long-term impact of the programme, which showed that at the age of entering college the pupils still showed more positive attitude towards STEM careers than their contrasts. Female scientists as role models and mentors were also used in a series of science and math workshops called "Girls in Engineering, Mathematics, and Science (GEMS)". The workshops offered hands-on activities to middle-school female pupils on weekends. The survey data showed that participant interest in science and math increased on average by 35 percent after attending a GEMS event (Dubetz & Wilson, 2013).

The notion of mentors and role models might be addressed both within the Ark of Inquiry project itself (though communities) and locally (through local mentors and role models).

## Scenario 5: Overcoming Language Barriers

The preparatory work for D2.3 Population of the Ark of Inquiry platform for piloting has shown that the language dependency of activities widely varies, and that adding/changing language is not always possible. At the same time it cannot be guaranteed, even if it were possible, that all activities can be translated into all languages of the Ark of Inquiry project (current partner languages, and potentially even beyond those). But this does not necessarily render all foreign language activities useless for users, as it also depends on the extent to which activities depend on language and the approach to language of teachers and schools. Formulated more practically, on the one hand, activities might be in a different language, but using them actually might require only very little real foreign language understanding, and on the other hand, teachers and schools might actually seize different language activities as an opportunity to integrate content and second language learning.

### Language dependency

The first case builds upon the idea that we might underestimate the flexibility of pupils in dealing with different language activities. This has already been noticed with the introduction of remote controls (children just start using them; like many adults, they do not read the manual) and can now be extended to tablets and other mobile devices (using them before even being able to read). This continues even after pupils start reading when interacting with foreign language applications (e.g., apps on their mobile phones). They are learning how to use them through experience and/or are helped by peers or others that are proficient enough to understand the language. It would be a pity not to foster this flexibility by excluding all foreign language activities by default.

It is for this reason that within the Ark of Inquiry the activities are also labelled according to their 'language dependency level'. Three levels of language dependency are distinguished (low, medium, and high), and broadly, these can be understood as low, meaning there is fairly little language understanding needed in the activity (e.g., concepts and words in a simulation interface that is self-directing through the design), medium as having more language involved, but the amount and the way it is incorporated in the activity allows relatively easy adaptation or work around (e.g., machine translation), and high, meaning that these strategies do not work and that it would require good understanding of the language and/or real effort to make it available in another language.

The rationale behind including a language dependency field is that it can be used as a search option when looking for suitable activities. As such it also serves as a means to make it more explicit that the language of an activity is a relative concept and that the fact that something is not in the native language does not disqualify an activity from being usable in many cases. The more practical reason for the language dependency field in the Ark of Inquiry is a very practical point in that it provides access to these activities that, even though not in the native language, could still be of interest because they could be used with relatively little effort.

Without an explicit option to search on language dependency, these activities would be overlooked in a search for activities in the native language only.

Figure 5 is an example of a low language dependency activity (see Scenario 2 for more background on the activity) that could be easily overlooked if one would only look for native language activities. Though the resource is not available in other languages than Dutch, the actual language dependency is not very high. The main concepts of importance are *soort* (species), *grafiek* (graph), *jaartal* (year), *aantallen per vangdag* (average amount caught per day), and the list of species. From these only the latter is more elaborate, but because the site also provides information on the Latin names (and pictures) for each of the species, even that does not need to be too big of a hurdle for using the resource. All necessary information could easily be provided on a sheet of paper that pupils can keep next to the computer when they use the resource. The basis for this translation could be provided by an automatic translation with one of the available translators on the Web, and then this translation could be improved where needed (the extent of the second step depends on both the quality of the initial translation and the language level understanding of the pupils). Doing so opens up an interesting resource that can be used for more or less structured inquiry activities (see Scenario 2 for examples) within a real-life environmental context.

### **CLIL - Content and Language Integrated Learning**

The second case, seeing second language activities as an opportunity rather than an obstacle, is rooted in some recent developments related to language learning in schools. In response to the realisation that it is beneficial for learning foreign languages to start at an early age, many countries are nowadays starting second language education at a younger age than before (e.g., 10–11 in the Netherlands, 9–10 in Finland). In parallel to this development schools in the Netherlands have started to integrate this second language education with their other education using the CLIL (Content and Language Integrated Learning; e.g., see <https://www.leraar24.nl/dossier/3035> for some background info and video illustrations) pedagogical framework. Within this approach, teaching domain specific knowledge and teaching foreign language are integrated (e.g., teaching science is done in English). The advantage of this approach is that the exposure to and use of the second language is increased without the need for allocating extra hours in the curriculum. Research related to CLIL shows that this increased use of foreign language in these settings does increase mastery in the second language without having detrimental effects on the development of the native language. The reason for adopting the CLIL approach is often twofold: it aims at increasing the outcomes of second language education, but often it is also seen as an opportunity to profile their school in order to attract pupils. From this perspective, activities in a second language are not a problem, but become an opportunity for fostering a more flexible attitude towards foreign languages by integrating second language learning with content learning in a different subject.

Including mentors and role models will be addressed within the Ark of Inquiry project itself (though the communities), but whenever possible, it might also be addressed locally in schools (through local mentors and role models).

### 3. Conclusions

This deliverable presented five initial pedagogical scenarios that are designed to enhance the uptake and use of inquiry activities across schools in Europe in the context of the Ark of Inquiry project. These scenarios that build on the existing work in the project are generic in nature, meaning that each scenario can be implemented in relation to any inquiry activity inside and outside of the project where the scenario applies to. The scenarios are targeted at teachers with the idea that the scenarios will help them to author, amend and adapt existing activities to fit these better to their specific needs and goals in the school environment. Even though the scenarios are targeted at teachers, they can also be used by other stakeholders to help them design and structure activities in such manner that the activities meet the general requirements of the Ark of Inquiry project. As the project evolves, based on experiences in and feedback from the teacher training and piloting, this initial pedagogical framework will be continuously revised and amended, and a final updated version of the framework (Pedagogical Scenarios), with broader scope of scenarios, will be presented in M24 (D2.4 Pedagogical inquiry scenarios for re-use of inquiry activities). The scenarios in this deliverable will also be a component in the Ark of Inquiry's support system (D1.4 Specification of support systems in Ark of Inquiry) and can be used by teachers to adapt and/or amend activities when they work with these activities during teacher training (WP4) in the Ark of Inquiry project.

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