4.5 Case study 5 (CS5 Greece)

Concept focus	Environmental impact of oil spills Behaviour of oil in water
Inquiry skills	Planning investigations Developing hypotheses Forming coherent arguments Working collaboratively
Scientific reasoning and literacy	Not assessed
Assessment methods	Classroom dialogue Teacher observation Peer-assessment Self-assessment Worksheets Presentations
Student group	**Grade:** lower second level **Age:** 12-13 years **Group composition:** mixed ability and gender; 17 students **Prior experience with inquiry:** No prior experience with inquiry

In this case study, students investigated both the effects of wind and current on the spread of oil and the environmental impact of an oil spill. The skills assessed during their investigations were *planning investigations*, *developing hypotheses*, *forming coherent arguments*, and *working collaboratively*. The teacher observed the students during the activities and provided feedback. The teacher prepared rubrics for use when assessing written artefacts, as well as instruments for peer- and self-assessment.

(i) How was the learning sequence adapted?

The **Black tide – oil in the water** SAILS unit was implemented as suggested by the unit, with some modifications. At the beginning of the lesson in order to warm-up the class the teacher showed two videos:

- *Knock Nevis* oil tanker (https://www.youtube.com/watch?v=LvjWZkM6ozU), which was the longest ship ever built, and
- Exxon Valdez oil spill (https://www.youtube.com/watch?v=7R_l-dqxBIc).

The teacher asked students to take notes about what they have observed in the videos. Then, the teacher provided the investigation problem to the students. Students were divided by the teacher into groups of 3-4 members of mixed skills level and mixed gender and the teacher described the steps of the research process.

The students had first to write a plan, in groups, for an experiment that would help them find an answer to the research question. The students were free to propose extra materials in addition to those suggested by the teacher. The students were enthusiastic and there were intense discussions. Many students focused on how much salt should be added to water to resemble the water of the ocean. The teacher realised that students had fixated on this factor because of his suggestion to take into consideration factors such as the salt in oceans. He asked them to do a small search on the internet for this information. Also, to motivate and stimulate students the teacher posed the following questions:

- What do you plan to observe?
- How will you measure it?
- In your plan, what things are you going to keep constant and why?

- What things are you going to change and why?

Although the students had no previous experience in inquiry, the teacher reported that all the plans were acceptable. After the discussions, the teacher asked students to write down their hypotheses – predictions of what will happen as a result of the experiment that they had planned. The teacher asked students to write a justification for each activity. At the end of the first period the teacher asked students to exchange their plans in order to do a peer-assessment. For this purpose, the teacher provided the students with a rubric that he had constructed before the lesson. The students had many questions about how to apply the rubric, especially the criteria concerning variables (independent, dependent, control), as they had no prior experience with these. Such criteria were difficult for them to handle for the peer-assessment. The teacher gave directions and explanations accordingly. Despite the students' difficulties, the whole process was successful and the students said that it was helpful to them to clarify several misconceptions.

The next lesson period was the experimental period where the teacher gave directions on how to perform some guided experiments. In the first experiment, the groups prepared the simulated oil, which they then added (in different amounts) to clean water and made observations (Figure 1). Then, the students had to generate ripples as well as to blow on the surface of polluted water. Also, they had to dip a feather in clean and polluted water and write down their observations. Finally, they had to use some detergent in order to observe if it will be easy to clean an oil slick and the feather. The teacher observed the groups during the experimentation and the way they collaborated and discussed. At the end of the lesson period the teacher asked the students to compare their findings with the predictions written in previous lesson period. The groups tried to make corrections with the help of the corresponding work sheet. The teacher worked supportively with each group (solving inquiries or disagreements). Finally, the teacher asked groups to prepare a presentation for the next lesson, which answers the initial question. The students were free to search on the internet in order to enrich and justify their report.

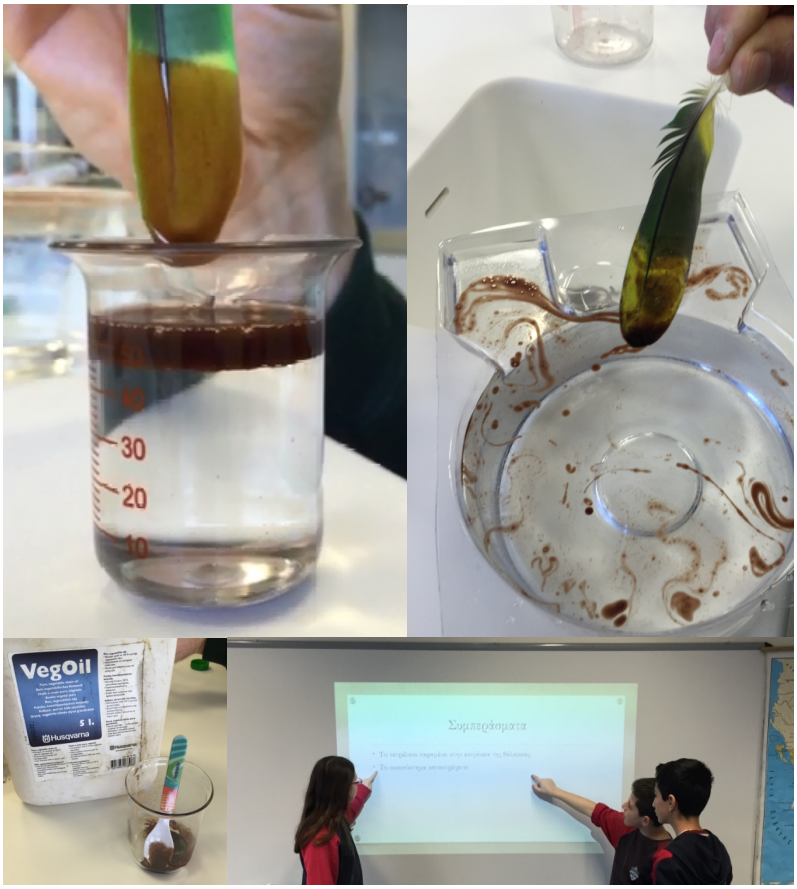


Figure 1: Images showing oil on water, effect of oil on a feather, preparation of simulated oil and student presentation.

Finally, in the last lesson period the teacher asked groups to present their reports in class and then carry out a peer-assessment. The teacher discussed with the students the rubric he had already prepared for the peer-assessment. This time the students demanded less help than the previous peer assessment phase and the teacher reported that the whole process was accomplished smoothly. Moreover, the teacher asked students individually to fill in a self-assessment questionnaire concerning the quality of their collaboration.

(ii) Which skills were to be assessed?

The following skills were assessed in this case study: *planning investigations*, *developing hypotheses*, *forming coherent arguments*, and *working collaboratively*. The teacher observed the students during the activities and provided feedback. The teacher prepared rubrics for use when assessing written artefacts, as well as peer- and self-assessment tools

(iii) Criteria for judging assessment data

Developing hypotheses and planning investigations

To assess students' skill in *planning investigations*, the students were asked to design an experiment that would help them find an answer to the research question. Classroom dialogue was used to provide formative feedback and the teacher posed questions to aid the students in forming their plans. Once the plans were prepared, students then had to write down the hypothesis that their plan would investigate. Their skill in *developing hypotheses* was assessed using a three-level rubric (Table 1). Groups exchanged their work plans and their peers assessed the plans using the peer-assessment tool, which details seven criteria for forming judgements (Table 2).

Table 1: Assessment of developing hypotheses (making predictions)

	1 – poor	2 – needs improvement	3 – good
Developing hypotheses	Presents prediction but without any justification	Presents prediction that is not fully justified or not clearly described. It does not explain fully his/her plan	Presents well justified predictions in a clear way. It fully explains his/her plan

Table 2: Peer-assessment of inquiry plans (planning investigations)

Assessment criteria	1 - poor	2 - acceptable	3 - good	Score
1. The description of the plan is clear	No	Needs improvement (some gaps exist)	Yes (no gaps)	
2. The plan includes independent variables	No	Needs improvement (some gaps exist)	Yes (no gaps)	
3. The plan includes dependent variables	No	Needs improvement (some gaps exist)	Yes (no gaps)	
4. The plan includes controlled variables	No	Needs improvement (some gaps exist)	Yes (no gaps)	
5. The plan takes into consideration natural factors (currents, waves, wind)	No	Needs improvement (some gaps exist)	Yes (no gaps)	
6. The plan takes into consideration living beings (such as seabirds)	No	Needs improvement (some gaps exist)	Yes (no gaps)	
7. The plan takes into consideration cleaning issues	No	Needs improvement (some gaps exist)	Yes (no gaps)	
			Total Score	

<u>Forming coherent arguments</u>

Two opportunities for assessment of *forming coherent arguments* were identified. First, following implementation of their planned experiments, the students had to revisit their predictions, and revise them based on the results they had obtained. This self-assessment was carried out using a simple form for guidance, as shown in Table 3. Again, the teacher engaged in classroom dialogue, providing support through questioning and resolving queries or disagreements.

Table 3: Comparison of prediction in relation to planning investigations (self-assessment tool)

The mistake was...			
The correct explanation is ...			
	I was right ☐	I edited it ☐	I rejected it ☐

The second opportunity for assessment of students' skill in *forming coherent arguments* was the final presentation. Here the groups presented their results (for example using MS PowerPoint or other multimedia resources), and their presentations were peer-assessed, using an assessment tool with five criteria (Table 4).

Table 4: Assessment of forming coherent arguments (peer-assessment tool)

Assessment criteria	1 - poor	2 - acceptable	3 - good
1. Does the answer seem right?	No	Needs improvement (some gaps exist)	Yes (no gaps)
2. Do they use arguments in order to convince you?	No	Needs improvement (some gaps exist)	Yes (no gaps)
3. Is the argumentation being used complete?	No	Needs improvement (some gaps exist)	Yes (no gaps)
4. Does the argumentation being used feel right?	No	Needs improvement (some gaps exist)	Yes (no gaps)
5. Did you like the presentation of the group?	No	Needs improvement (some gaps exist)	Yes (no gaps)

Working collaboratively

To assess the skill of *working collaboratively*, the students completed a self-assessment questionnaire (Table 5). This allowed them to reflect on their role in the group, and to identify their strengths and weaknesses when working in a team.

Table 5: Self-assessment of working collaboratively

Assessment criteria	3 - always	2 - sometimes	3 - rarely
1. I actively participated in all discussions of the group			
2. In all discussions I took into consideration the views of all team members			
3. I helped in resolving disputes between team members			
4. I used convincing arguments to support my views			
5. I provided assistance in the team whenever needed			
6. I looked for information on the subject throughout the activity			
7. I completed without delay all the work undertaken to do in the team			

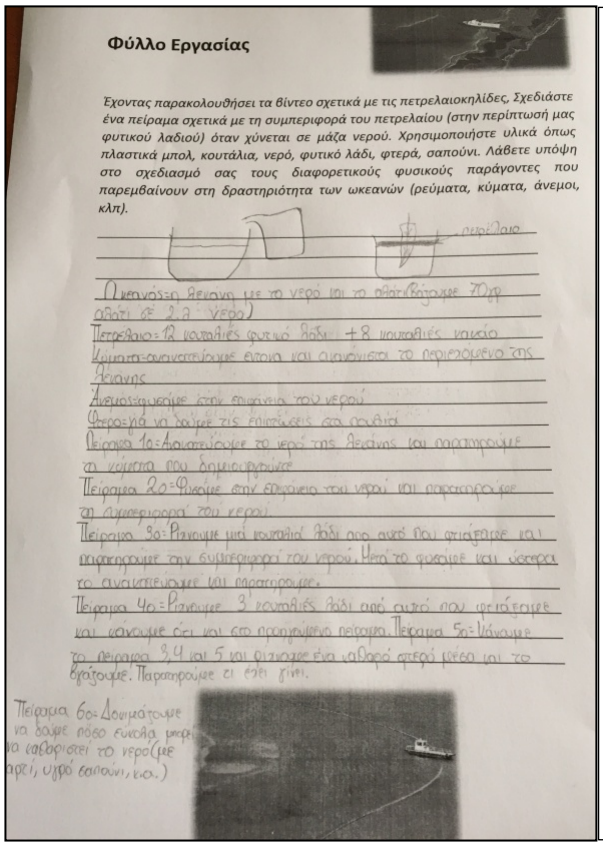
(iv) Evidence collected

Teacher's opinion

The teacher reported that it was a successful experience and the students really enjoyed the inquiry lesson. Before the class, the teacher prepared all assessment instruments. During the class, the teacher discussed all the assessment instruments with the students. The students showed great interest throughout the course. They did not experience any notable difficulties, except when using the rubric for assessment of inquiry plans (Table 2). The students had difficulty understanding the criteria concerning variables (independent, dependent, control). This was understandable, as the students had no prior experience in inquiry or peer-assessment.

Sample student artefacts

Shown in Figure 1, are some photographs taken during the inquiry activity. Examples of work plans devised by students are shown in Figure 2 and Figure 3. Figure 2 scores best, as the plan is comprehensive.

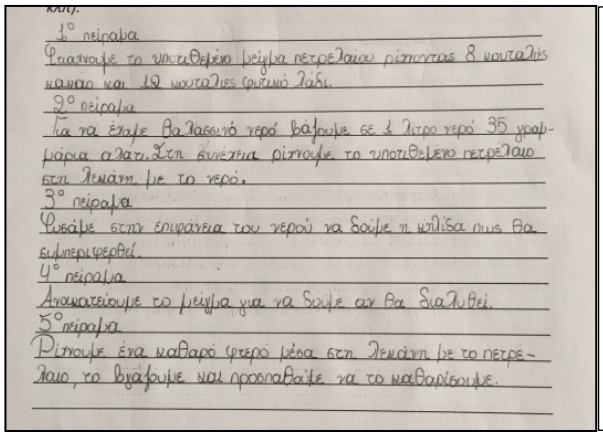

Φύλλο Εργασίας

Έχοντας παρακολουθήσει τα βίντεο σχετικά με τις πετρελαιοκηλίδες, Σχεδιάστε ένα πείραμα σχετικά με τη συμπεριφορά του πετρελαίου (στην περίπτωσή μας φυτικού λαδιού) όταν χύνεται σε μάζα νερού. Χρησιμοποιήστε υλικά όπως πλαστικά μπολ, κουτάλια, νερό, φυτικό λάδι, φτερά, σαπούνι. Λάβετε υπόψη στο σχεδιασμό σας τους διαφορετικούς φυσικούς παράγοντες που παρεμβαίνουν στη δραστηριότητα των ωκεανών (ρεύματα, κύματα, άνεμοι, κλπ).

Πειραμα 6ο=Δοκιμάσουμε να δούμε πόσο εύκολα μπορ να καθαρίσουμε το νερο(με αφρι, υγρό σαπούνι, κ.α.)

Ocean = the basin with 2 L water and 70 g salt.
Simulated oil = 12 spoons vegetable oil + 8 spoons cocoa powder.
Waves = we stir vigorously and irregularly the water in the basin.
Winds = we blow on the water surface
Feathers = to check the consequences in seabirds
1st Experiment = we stir the water in the basin and we observe the waves created.
2nd Experiment = we blow on the surface of the water and we observe the results.
3rd Experiment = Pour one spoon of simulated oil in the water and observe what will happen. After that we blow on the surface of the water and observe carefully. Finally, we stir the content and leave it for a while to calm. Observe
4th Experiment = Pour three spoons of simulated oil in the water, we do the same as in previous
5th Experiment = Pour six spoons of simulated oil in the water and we do the same as in previous
6th Experiment = the same experiment with 3,4 and 5 but now we sink a clean feather to see what will happen.
Final Experiment = we try to clean the feather by using paper, soap and detergent

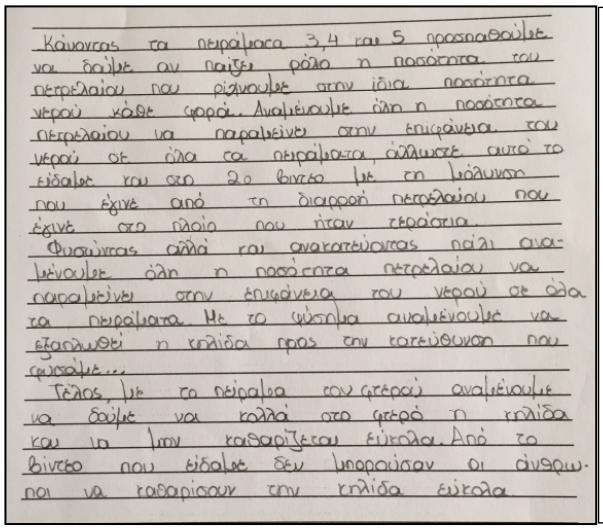
Figure 2: Example of planning investigations


1° πείραμα
Φτιάχνουμε το υποθετικό μείγμα πετρελαίου ρίχνοντας 8 κουταλιές καφέ και 12 κουταλιές φυτικό λάδι.
2° πείραμα
Για να έχουμε θαλασσινό νερό βάζουμε σε 1 λίτρο νερό 35 γραμμάρια αλάτι. Στη συνέχεια ρίχνουμε το υποθετικό πετρέλαιο στη λεκάνη με το νερό.
3° πείραμα
Φυσάμε στην επιφάνεια του νερού να δούμε η κηλίδα πως θα συμπεριφερθεί.
4° πείραμα
Ανακατεύουμε το μείγμα για να δούμε αν θα διαλυθεί.
5° πείραμα
Ρίχνουμε ένα καθαρό φτερό μέσα στη λεκάνη με το πετρέλαιο, το βγάζουμε και προσπαθούμε να το καθαρίσουμε.

1st Experiment = we make the simulated oil by using 12 spoons vegetable oil + 8 spoons cocoa powder
2nd Experiment = In order to make ocean water we throw 35g salt in 1 L water. Then we pour the simulated oil into the ocean water.
3nd Experiment = we blow on the surface of the water and we observe how the oil behaves.
4th Experiment = we stir the water and oil and check what will happen.
5th Experiment = Sink a feather in the polluted water and then try to clean it.

Figure 3: Example of planning investigations

Shown in Figure 4 and Figure 5 are some examples of the predictions made by student groups. The first example shows a higher performance level than the second, as it is well detailed and contains some justification.



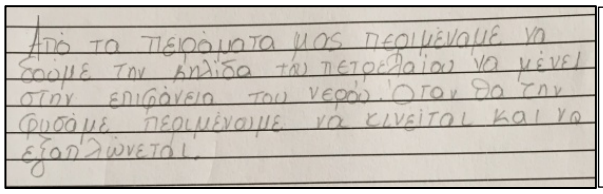
Κάνοντας τα πειράματα 3,4 και 5 προσπαθούμε να δούμε αν παίζει ρόλο η ποσότητα του πετρελαίου που ρίχνουμε στην ίδια ποσότητα νερού κάθε φορά. Αναμένουμε όλη η ποσότητα πετρελαίου να παραμείνει στην επιφάνεια του νερού σε όλα τα πειράματα, αλλιώστε αυτό το είδαμε και στο 2ο βίντεο με τη διάλυση που έχυνε από τη διαρροή πετρελαίου που έχυνε στο πλοίο που ήταν κεφάτσια. Φυσώντας αλλά και ανακατεύοντας πάλι αναμένουμε όλη η ποσότητα πετρελαίου να παραμείνει στην επιφάνεια του νερού σε όλα τα πειράματα. Με το φύσημα αναμένουμε να εξαπλωθεί η κηλίδα προς την κατεύθυνση που φυσάμε...

Τέλος, με το πείραμα του φτερού αναμένουμε να δούμε να κολλά στο φτερό η κηλίδα και να μην καθαρίζεται εύκολα. Από το βίντεο που είδαμε δεν μπορούσαν οι άνθρωποι να καθαρίσουν την κηλίδα εύκολα

By doing the experiments 3-5 we try to check if the amount of oil affects the behaviour of the solution. We expect that the whole quantity of oil will remain in the surface of the water in all experiments. Indeed, we have seen this in the 2nd video...

... By blowing as well as by stirring the water we expect after some time to see again the whole quantity of oil to remain in the surface of the water. By blowing we expect the oil to move in the direction we blow. Finally, by doing the experiments using the feather we expect to see the oil sticking to the feather. As we saw in video, the scientist hardly managed to clean the oil from the feathers of the seabirds.

Figure 4: Example of developing hypotheses (making predictions)

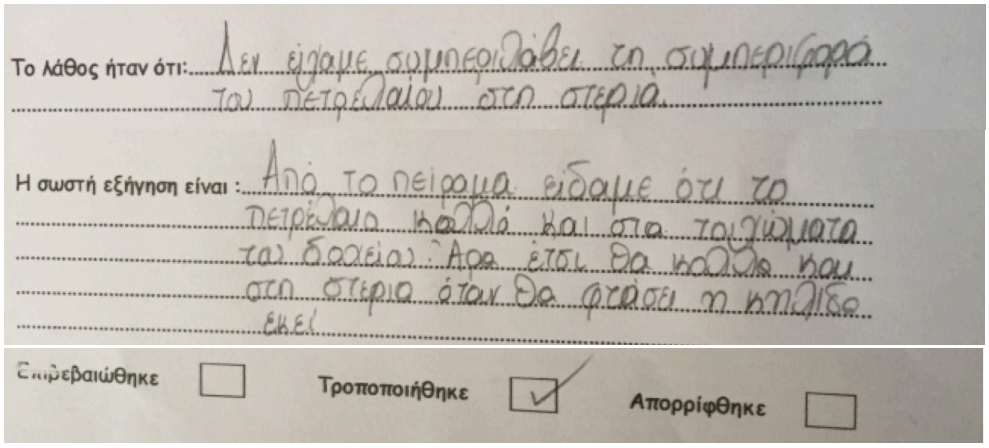


Από τα πειράματα μας περιμένουμε να δούμε την κηλίδα του πετρελαίου να μένει στην επιφάνεια του νερού. Όταν θα την φυσάμε περιμένουμε να κινείται και να εξαπλώνεται.

From all the experiments we expect to see the oil to remain on the surface of the water. When we blow the oil it will move following the direction of the wind but it will remain on the surface of the water

Figure 5: Example of developing hypotheses (making predictions)

Students used a worksheet to record their predictions, and at the end of the exercise they tested their predictions. They could make modifications, based on the results obtained. Figure 6 and Figure 7 show examples where the groups modified their hypotheses.



Το λάθος ήταν ότι: Δεν είχαμε συμπεριλάβει τη συμπεριφορά του πετρελαίου στη στεριά.

Η σωστή εξήγηση είναι: Από το πείραμα είδαμε ότι το πετρέλαιο κολλά και στα τοιχώματα του δοχείου. Άρα έτσι θα κολλάει και στη στεριά όταν θα φτάσει η κηλίδα εκεί.

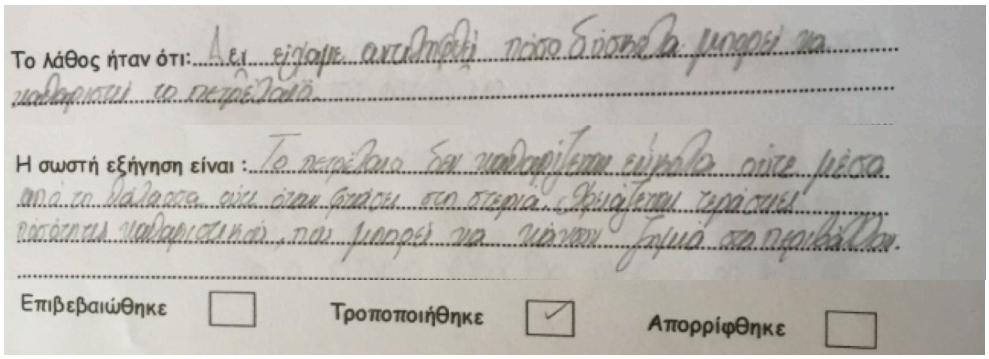
Επιβεβαιώθηκε ☐ Τροποποιήθηκε ☑ Απορρίφθηκε ☐

The mistake was: ***We didn't include the behaviour of the oil in the land in our plan...***

The correct answer is: ***From the experiment we saw that oil stuck to the surface of the basin so when it will reach the seashore or the rocks it will stick on them.***

Verified ☐ Modified ☑ Rejected ☐

Figure 6: Example of testing a hypothesis



The mistake was: ***We didn't realise how difficult it is to clean up oil.***
The correct answer is: ***The clean-up of oil is difficult both at sea and on land. A huge amount of detergent is needed and this is a risk to the environment.***

Verified ☐ Modified ☑ Rejected ☐

Figure 7: Example of testing a hypothesis

(v) Use of assessment data

The teacher found the unit very motivating. He decided to focus and prepare more inquiry lessons at the next cohort. He believes that it is practically possible to assess inquiry skills in classroom and now he feels more confident with himself in assessing inquiry skills. He also considers that inquiry can be easily cultivated but we need to make fundamental changes into our curricula. Especially in Greece we need to decrease the large extends of cognitive content in order to invest time in well-organised inquiry lessons.

(vi) Advice for teachers implementing the unit

New teachers need to be well prepared in inquiry methods and tools. They have to become inquiry learners themselves in order to understand the principles of inquiry and after that they have to focus on the way they can assess inquiry skills. Well-prepared inquiry units are also necessary for this purpose.