4.2 Case study 2 (CS2 Greece)

Concept focus	Environmental impact of household chemicals
Inquiry skills	Planning investigations Forming coherent arguments
Scientific reasoning and literacy	Not assessed
Assessment methods	Classroom dialogue Teacher observation Peer-assessment Worksheets Presentations
Student group	**Grade:** lower second level **Age:** 13-14 years **Group composition:** mixed ability and gender; 21 students **Prior experience with inquiry:** No prior experience with inquiry

In this *guided inquiry*, the teacher used online video resources to engage the students and to begin a class discussion about cleaning agents and the environment. The skills assessed in this case study were *planning investigations* and *forming coherent arguments*. The teacher used the suggested rubrics to evaluate worksheets and presentations. She also observed the students during the activities and gave formative feedback. The students carried out peer-assessment, using a rubric provided by the teacher.

(i) How was the learning sequence adapted?

The **Household versus natural environment** SAILS unit was implemented in as suggested by the unit, with little modification. The teacher started the lesson by announcing to the students the investigation problem. In order to warm up the class, the teacher presented two short videos:

- How the cleaning agents are made (in Greek)
  https://www.youtube.com/watch?v=t8VsYseIV8c
- Advertisement for an environment-friendly detergent (in Greek)
  https://www.youtube.com/watch?v=EQjX3nf32As

Then, the teacher started a discussion on the possible consequences of the use of the various cleaning agents on the environment. Firstly, she asked students to "List cleaning and washing agents which your families use at home" and then she posed the question "What would happen if we discharged our wastewater into the environment without subjecting it to any sort of treatment beforehand?" The students were motivated and they had much to discuss. This activity lasted for 15 minutes, during which the teacher observed students' engagement and their prior knowledge on the subject. According to the teacher, the majority of students reported more than one cleaning agent, they generally mentioned the bad consequences into the environment but they did not manage to formulate scientific explanations well, with the exception of 2-3 good students.

Then the teacher asked the students to continue their investigation on the subject by designing an experiment with which they could investigate the effect of a cleaning agent on the growth of plants. She also asked to form groups of 3-4 members in order to work in teams. The teacher posed the following questions:

- What would you like to investigate? What would you look for?
- Can you identify/define some factors?
- Can you formulate a hypothesis of the impact of the investigated factors?
- How can you check your prediction?
- What do you think you will observe or measure and in which way?

The teacher reported that students were very enthusiastic during this phase and all the groups showed intense discussions on the subject. The students wrote their plans in the appropriate worksheet and the teacher proceeded to the experimentation phase. In Greece, according to the framework established by the Institute of Educational Policy, teachers have been instructed to use guided experiments. Therefore, the teacher proceeded to the suggested guided experiment. She analytically presented the steps of the experiment and she answered several questions from the students. Finally, she asked students to carry out the experiment, collect and record their observations and prepare a presentation at the final lesson. In the final lesson (two weeks after the first lesson), the teacher firstly asked students to do a small presentation of their work to the class and then she asked students to exchange their work in order to compare and discuss the results. Finally, the teacher summarised the whole findings, she gave feedback to students and asked them to make a peer-assessment. She discussed with the students the proposed rubric, in order to use it for their assessments. The students showed that they had many difficulties in understanding how to apply the criteria of the rubric, and they needed a lot of guidance from the teacher. However, at the end of the activity, they said that they liked the whole process. The teacher reported that this was the first time that the students had carried out such an activity, and they need time to become familiar with it.

(ii) Which skills were to be assessed?

The skills assessed in this case study were *planning investigations* and *forming coherent arguments* (assessment of data presentation). The teacher used the suggested rubrics on the written artefacts. She also observed the students during the activities and gave feedback.

(iii) Criteria for judging assessment data

The teacher used the suggested rubrics for *planning investigations* (Table 1) and for presentation of data (Table 2), as outlined in the unit. No changes were made to either rubric.

Table 1: Assessment of planning investigations

Poor	Acceptable	Good	Excellent
The student... proposes a cleaning agent and a plant, enumerates 1-2 steps of inquiry,	and... proposes a factor/variable to investigate, enumerates basic steps of inquiry,	and... formulates a hypothesis, enumerates almost all steps of inquiry, considers standardisation of a procedure	and... proposes a consistent and completed procedure.

The students did not have any previous experience in inquiry lessons and their answers were a bit unformed. All the groups managed to propose a cleaning agent, a plant and a basic set of inquiry steps. The teacher reported that no students reached the “excellent” performance level. All the students expected to observe the harmful effect on the development of the plant but their plans did not include enough detergent solutions in order to identify the point of the harmful effect.

Table 2: Assessment of forming coherent arguments – presentation of scientific data

Poor	Acceptable	Good	Excellent
The student presents results only in descriptive way. Presents incomplete or incorrect conclusions without supportive evidence	The student presents results in the form of a table or graph. Draws conclusions, but not completely correctly	The student presents results in the form of table and graph. Draws appropriate conclusions but not fully supported by arguments and evidence.	The student presents results in the form of table and graph. Draws appropriate conclusions. Supports conclusions, using reasoned arguments and evidence. Identifies possible sources of inconsistency.

(iv) Evidence collected

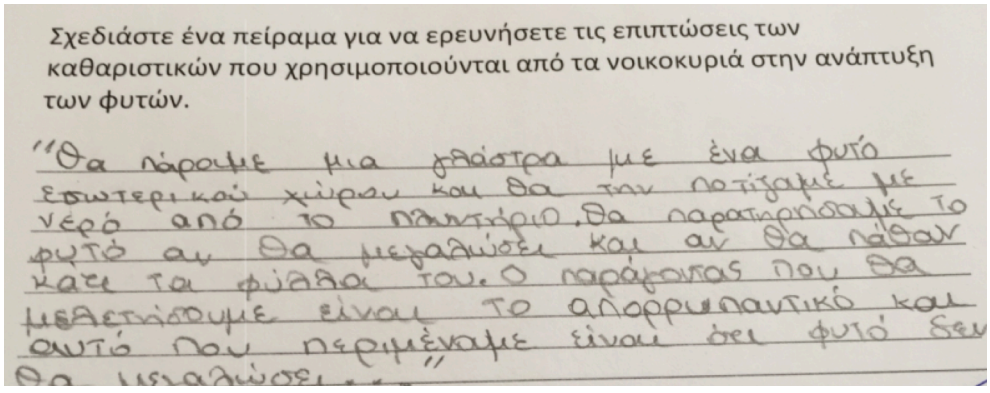
Teacher's opinion

The teacher reported that students really enjoyed the inquiry lesson. The students did not have any previous experience in inquiry lessons and they asked from teacher to organise more such lessons.

The teacher used the suggested rubric sheets that she had already studied before the class. She reported that it was very useful during the assessment of the students' work. However, this rubric was not easy for the students to use during the peer-assessment. The teacher believes that it was not a problem of the rubric itself, but rather a problem of the maturity of the students in this kind of assessment. She reported that students liked the activity despite the problems they had. She believes that students need time and practice in order to become familiar with such activities.

Sample student artefacts

The following are some sample student artefacts:


Σχεδιάστε ένα πείραμα για να ερευνήσετε τις επιπτώσεις των καθαριστικών που χρησιμοποιούνται από τα νοικοκυριά στην ανάπτυξη των φυτών.

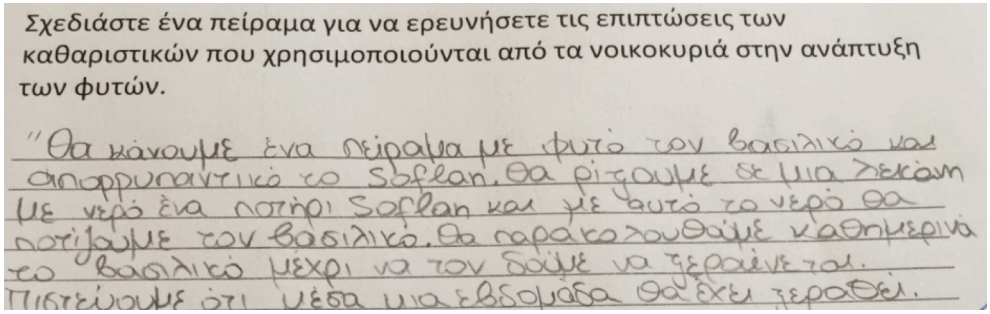
"Θα πάρουμε μια γλάστρα με ένα φυτό εσωτερικού χώρου και θα τον ποτίζαμε με νερό από το πλυντήριο. Θα παρατηρούσαμε το φυτό αν θα μεγαλώσει και αν θα πάθαν κάτι τα φύλλα του. Ο παράγοντας που θα μελετούμε είναι το απορρυπαντικό και αυτό που περιμένουμε είναι ότι φυτό δεν θα μεγαλώσει..."

Devise an experiment with which you can investigate the effect of a cleaning agent on the growth of plants.

We will take a pot containing an indoor plant and we will irrigate the plant with water from the laundry. We will observe if the plant will grow and whether its leaves will develop something bad. The factor that we will study is the detergent and what we expect is that the plant will not grow...

Figure 1: Example of planning an investigation (acceptable level).

Most students proposed an experiment with an indoor plant and water from the washing machine as above. They expect that the plant will not grow.


Σχεδιάστε ένα πείραμα για να ερευνήσετε τις επιπτώσεις των καθαριστικών που χρησιμοποιούνται από τα νοικοκυριά στην ανάπτυξη των φυτών.

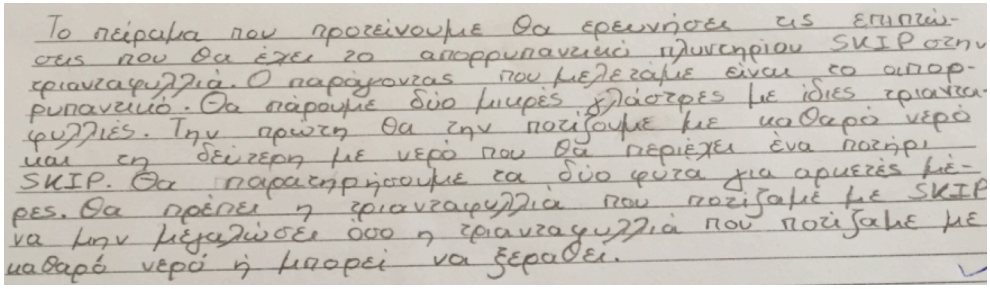
"Θα κάνουμε ένα πείραμα με φυτό τον βασιλικό και απορρυπαντικό το Soflan. Θα ρίξουμε σε μια λεκάνη με νερό ένα ποτήρι Soflan και με αυτό το νερό θα ποτίζουμε τον βασιλικό. Θα παρακολουθούμε καθημερινά το βασιλικό μέχρι να τον δούμε να ξεραίνεται. Πιστεύουμε ότι μέσα μια εβδομάδα θα έχει ξεραθεί.

Devise an experiment with which you can investigate the effect of a cleaning agent on the growth of plants.

We will do an experiment using a basil plant and the detergent Soflan. We will pour a cup of Soflan in a basin full of water and we will use this water for the watering of the basil. We will monitor daily the basil until we see the withering of the plant. We believe that this will happen in one week.

Figure 2: Example of planning an investigation (acceptable level).

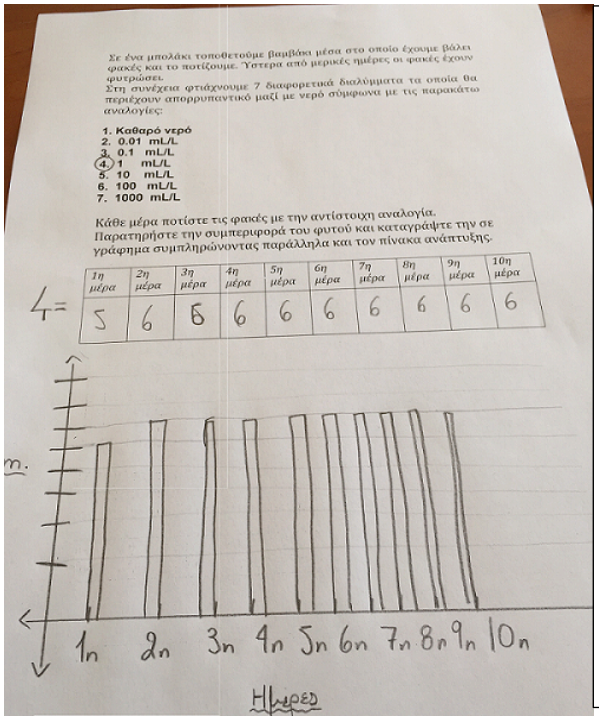
In the example shown in Figure 2, the group proposes an experiment using a specific plant (basil) and a specific detergent (Soflan). They try to propose a detergent solution without justification. Each day they will observe the basil. Their hypothesis is that basil will die some day. This example was assigned a performance level of "acceptable". An example of student performance at the "good" level is shown in Figure 3, in which students propose to study the effect of detergent on the growth of rose bushes. They suggest the use of a control, where a comparison is made with a bush treated with water.


Το πείραμα που προτείνουμε θα ερευνήσει τις επιπτώσεις που θα έχει το απορρυπαντικό πλυντηρίου SKIP στη τριανταφυλλιά. Ο παράγοντας που μελετάμε είναι το απορρυπαντικό. Θα πάρουμε δύο μικρές γλάστρες με ίδιες τριανταφυλλιές. Την πρώτη θα την ποτίζουμε με καθαρό νερό και τη δεύτερη με νερό που θα περιέχει ένα ποτήρι SKIP. Θα παρατηρήσουμε τα δύο φυτά για αρκετές μέρες. Θα πρέπει η τριανταφυλλιά που ποτίζαμε με SKIP να μην μεγαλώσει όσο η τριανταφυλλιά που ποτίζαμε με καθαρό νερό ή μπορεί να ξεραθεί.

We propose an experiment in order to investigate the impact of the SKIP detergent on rosebushes. We will use two same pots with rosebushes. In the first one we will pour clean water while in the second one the water will contain a beaker of SKIP. We will observe the two plants for several days. We expect that at the second pot the rosebush will grow slower than the first one or it may die.

Figure 3: Example of planning an investigation (good level).

The next pictures show some worksheets containing graphs and conclusions based on the students' observations.



In a bowl we put cotton and then we add lentils and start watering. After a few days lentils will have sprouted.
Then we make seven different solutions that contain a detergent according to the following proportions:
1. Clean water
2. 0,01 mL/L
3. 0,1 mL/L
4. 1 mL/L
5. 10 mL/L
6. 100 mL/L
7. 1000 mL/L
Every day you have to irrigate lentils using the corresponding solution. Observe the behaviour of the plant by recording the growth in the corresponding table and also by constructing an appropriate graph.

Table of results shown and graph plotted

Figure 4: Example of a graph of student work.

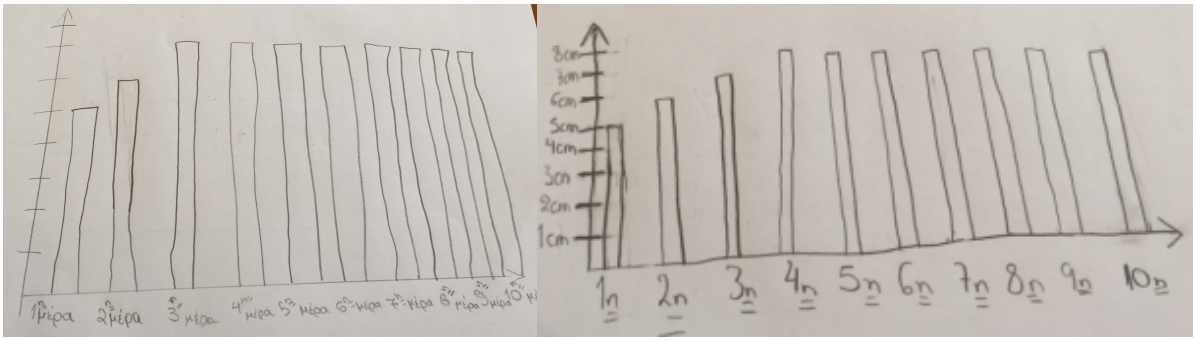
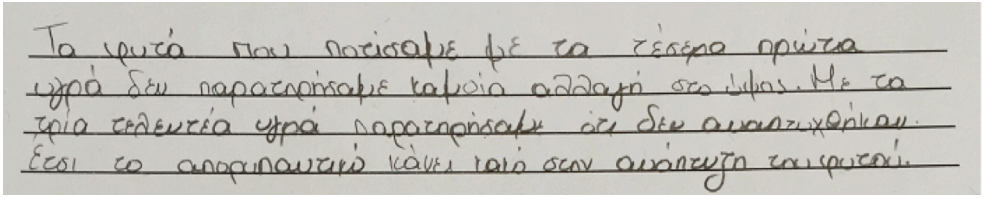
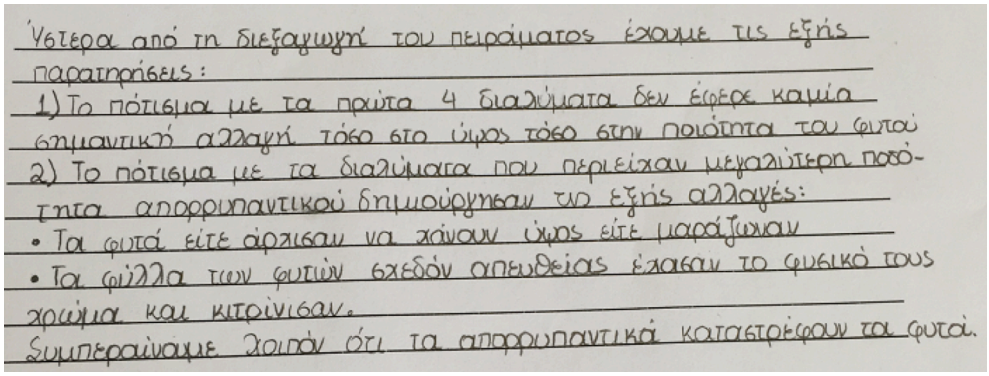


Figure 5: Examples of student graphs showing days on x-axis and height of plant on y-axis



We observed no change in the height of the plants that were irrigated using the first four solutions. Using the last three solutions we noticed that the plants stopped growing. Therefore we conclude that the detergent is harmful for plant growth

Figure 6: Example of conclusions.


Υστερα από τη διεξαγωγή του πειράματος έχουμε τις εξής παρατηρήσεις:
1) Το πότισμα με τα πρώτα 4 διαλύματα δεν έφερε καμία σημαντική αλλαγή τόσο στο ύψος τόσο στην ποιότητα του φυτού
2) Το πότισμα με τα διαλύματα που περιείχαν μεγαλύτερη ποσότητα απορρυπαντικού δημιούργησαν τις εξής αλλαγές:
• Τα φυτά είτε άρχισαν να χάνουν ύψος είτε μαράζωναν
• Τα φύλλα των φυτών σχεδόν απευθείας έχασαν το φυσικό τους χρώμα και κιτρίνισαν.
Συμπεραίνουμε λοιπόν ότι τα απορρυπαντικά καταστρέφουν τα φυτά.

After conducting the experiment we make the following observations:
1) Watering using the first 4 solutions did not bring any significant change both in the plant height and in the plant appearance
2) Watering using solutions containing greater amount of detergent led to the following changes:
- Either the plants began to lose height or to languish
- Plant leaves lost their natural colour and became yellowed
So we conclude that detergents can destroy the plants.

Figure 7: Example of conclusions.

The majority of the students showed an acceptable data presentation. However, there were several gaps and weaknesses especially in the students' argumentation.

(v) Use of assessment data

The teacher reported that the second lesson was the most productive lesson, when they discussed all the findings. The experiences of students formed the lesson's objectives. They learned new terms, especially "active ingredient," and learned how household cleaning products can affect their lives.

The teacher enjoyed the whole experience. She reported that the materials from the unit were very useful, because they helped her to understand how to focus on the underlying skills. She reported that it would be very useful to have more material of this kind.

(vi) Advice for teachers implementing the unit

A new teacher needs well-prepared learning materials, like the previous mentioned in order to start apply IBSE in his/her class.