

4.3 Case study 3 (Portugal)

Concept focus	Environmental impact of household cleaners
Inquiry skills	Developing hypotheses Working collaboratively
Scientific reasoning and literacy	Not assessed
Assessment methods	Classroom dialogue Teacher observation Self-assessment Worksheets Student devised materials (“natural” soaps and detergents)
Student group	Grade: 9 th grade; lower second level (voluntary participation) Age: 13-16 years Group composition: mixed ability and gender (4 girls, 3 boys) Prior experience with inquiry: No prior experience with inquiry

This case study details an adaptation of the unit, in which students first addressed the research question “How can we contribute to raising awareness within the educational community to the issue of the environmental impact of human activity?” before preparing “green” detergents. They then searched for information on their biodegradability. Two key skills were assessed – *working collaboratively* and *developing hypotheses*. The teacher provided both oral and written formative feedback and the students self-assessed their teamwork.

(i) How was the learning sequence adapted?

The **Household versus natural environment** SAILS unit was implemented as an optional laboratory exercise, which took place at the physical chemistry laboratory out of the students scheduled timetable. Students were invited to attend if they had free time and wanted to participate in laboratory work. The implementation took place over three 50-minute lessons, which were 2-4 days apart. To aid in guiding the inquiry, the teacher prepared a student worksheet (Figure 1). Students worked in two student-selected groups, of three and four members. One group was mixed-gender and the other was a single-sex group (girls).


The teacher made several adaptations to the unit for this implementation. Using a worksheet as a guide, the students were invited to answer the question “How can we contribute to raising awareness within the educational community to the issue of the environmental impact of human activity?” Students then engaged in a whole-class or group discussion to identify the key ideas emerging from this problem and searched online for information regarding how growth of human populations is affecting rivers and oceans around the world. The second phase (planning investigations) was then focused on identification of chemicals with a high impact on the environment, and proposing alternatives for these. Students were led to consider cleaners and detergents. They then prepared “natural” detergents and investigated their biodegradability using online resources. In one example, “natural” soaps were synthesised from blue and white soap waste and natural flavours or additive (lavender leaves, flower petals, decorative berries, coconut shavings, etc.). Another example was preparation of bath salts using salt and various scents brought from home). In another group, the students prepared a cleaning product using water, vinegar and lemon. To investigate the biodegradability of the prepared cleaners, the students carried out a search on the internet.

When implementing this task, the teacher followed the “5Es model” – engage, explore, explain, elaborate and evaluate.

1. Engage: Students were invited to answer the question regarding the environmental impact of human activity: “How can we contribute to raise awareness of this problem within the educational community?”
2. Explore: Students searched for background information to identify the effect of demographic growth on the composition of effluents that flow into rivers and oceans. The problem identified should address domestic effluents, because students are told to focus on what goes on at their school. The aim is to lead students to identify chemical cleaners as one of the problems that generate environmental imbalances in waterways and to raise an explanatory hypothesis for the impact of those chemical cleaners on the environment. Students then plan an investigation to propose an alternative to this problem and carry out the proposed experiment.
3. Explain: Students were asked to explain why they consider the activity they carried out to be an alternative to the problem. The aim is to lead the students to investigate the chemical composition of some detergents and its environmental impact.
4. Elaborate: Students are guided to investigate the chemicals in “green” detergents, and compare them to those that are not biodegradable.
5. Finally, at the “evaluate” stage, students communicate their alternative solution to the educational community; they also assess the activity and their learning.

Household versus natural environment

1. **Read carefully the introduction to the task that we will perform.**
Human activity has a high environmental impact. When substantial quantities of foam are detected in rivers and oceans it is a sign that something is wrong! How can we contribute to raise awareness of this problem within the educational community?
2. **Orally identify the key ideas that emerge from this problem.**
3. **Search for information to identify what is the effect of demographic growth on the composition of wastewater that flow into the rivers and oceans of our planet.**
4. **Carry out an investigation at your school.**
 - 4.1 Identify some of the chemicals with high environmental impact that end up being transported in wastewater.
 - 4.2. Raise possible explanations – hypothesis – regarding the environmental harmfulness of the chemicals you have identified in the previous question.
 - 4.3. Plan an activity which serves as an alternative to the problem.
 - 4.4. Carry it out.
5. **Investigate the decomposition of the product you have synthesised and compare it with the decomposition of products used in your school. Conclude.**
6. **Communicate your solution to the school’s governing bodies and to the rest of the educational community.**
7. **What have you learned with this activity?**
8. **What were the difficulties you have felt?**
9. **What did you enjoy the most?**



Environment friendly? Of course. But no excesses

Figure 1: Student worksheet for CS3 Portugal

(ii) Which skills were to be assessed?

Two key skills were identified for assessment during this implementation – *working collaboratively* (teamwork) and *developing hypotheses*. Throughout the process, the teacher constantly gave oral feedback to all working groups. After the task was accomplished, the teacher assessed the students’ written productions and provided them with written feedback on the students’ worksheet. At the

end of the activity, the members of the groups individually completed an opinion questionnaire regarding teamwork.

(iii) Criteria for judging assessment data

The assessment was formative for both skills. The teacher observed how the students performed in the inquiry tasks, and assessed their performance level in the selected skills. These skills were discussed in advance. Assessment criteria were defined according to the rubrics for the selected skills (Table 1).

Table 1: Assessment criteria for working collaboratively and developing hypotheses

Inquiry skills	Emerging	Developing	Consolidating	Extending
Teamwork Interpersonal relationships and group functioning (emotional literacy)	The student observes and accepts their colleagues' proposals in the structuring of the group work, but gives no suggestions; merely accepts what the colleagues are doing (due to difficulties in interpersonal relationships).	The student participates in the structuring of the group work, but only makes one or two suggestions that add little value to what was already done (due to difficulties in interpersonal relationships).	The student participates in the structuring of the group work and gives positive suggestions contributing to a productive group dynamic.	The student participates in the structuring of the group work and significantly contributes to a productive group dynamic, creating positive personal interactions (allowing the improvement of others and raising the work level).
Developing hypotheses	The student formulates hypotheses that are not consistent with the planning or that are not eligible for investigation.	The student formulates hypotheses that are consistent with the planning of the experiment.	The student formulates hypotheses that are consistent with the planned experiment and are based on the research questions.	The student formulates hypotheses that are consistent with the planned experiment. Those hypotheses are based on the research questions and variables are identified.

Working collaboratively (teamwork)

The teacher expected that students would be able to work with diverse groups, produce ideas based on views from team members, and take into account and deal with disagreements. Students should be able to manage time, workload and agree procedures.

During the lessons, the teacher sought to identify if students involved in teamwork showed appropriate interpersonal skills (those which allow them to work properly in a group with peers) and teamwork skills (regarding the way they structured the group work and the dynamics they created within the group). The teacher used a registration grid, in which the teacher noted the behaviours of each student and recorded the frequency of which they were observed (Table 2).

Analysis of the student opinion questionnaires revealed that the students always said all they wanted to say, their colleagues understood them, and they were capable of listening to others. Students' opinions were shared and did not trigger any conflicts. Some students said they changed

their points of view after the exchange of ideas with their colleagues. The student-student and teacher-student relationships were very good and discussions took place without constraints.

Table 2: Registration grid for observation of working collaboratively (teamwork)

Behaviour	Student name	Student name	Student name	Student name
Does not interrupt when others speak				
Questions the colleague regarding what he is saying				
Defends his points of view				
Talks with kindness				
Challenges a quieter colleague to speak				
Congratulates the colleagues when they present a positive idea				
Assumes an active role in order to solve conflicts between colleagues				
Defines/clarifies the work's objectives				
Defines/distributes/negotiates tasks among colleagues				
Draws attention to time				
Faced with distractions draws the group's attention to the work				

Developing hypotheses

The teacher expected that students would develop a hypothesis, which provides a link to the research question and includes a justification for that hypothesis. During assessment, the teacher sought to identify the level of scientific knowledge, cognitive skills and the ability to use scientific language.

(iv) Evidence collected

Teacher's opinions

The teacher created a diary when developing the task, and recorded entries throughout the activity, which she used for reflection. One example of the teacher's opinion, noted in the diary during the class is shown in Figure 2. The teacher found that the observation worksheet was easy to fill out and was essential for the students' final evaluation.

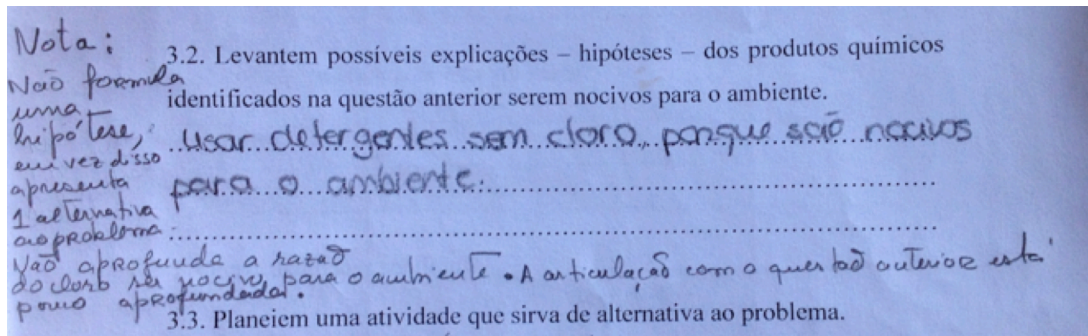
Some students showed difficulties in searching for information (there were no suggested websites; the students were in charge of this assignment). The students did not commit themselves to reading the texts and writing the answers; they have read and wrote as little as possible. These two aspects prevent students from deepening their knowledge, understanding information, and producing complete answers. This fact is corroborated by the comments of the natural sciences teacher of this class: "I had to force them to read... they wanted me to answer!" The natural sciences teacher also stated that students select as little information as possible to answer the questions. In the future, as a motivation strategy, research should be mainly done in the computer because students like to use it.

I also witnessed that students were very restless and excited with the idea of working in the laboratory. Students are not used to formulating hypotheses or working in groups. The great incentive for students to perform this task consisted in synthesising the product. This phase of the task was the driver for their strong involvement. I noticed that they were so excited about the prospect of putting their "hands-on" that they did everything in a hurry. Students are not familiar with this sort of task nor with conducting laboratory experiments, much less being themselves the ones to plan the activity. This experience showed that they like to do it. The great excitement and agitation of the students can be explained by the task novelty that empowers and enables them to put their "hands-on."

Figure 2: Example of teacher opinion extracted from reflective diary

Sample student artefacts

In the example shown in Figure 3, the teacher comment on the left side notes that the "students did not formulate a hypothesis; instead they presented an alternative to the problem, since they indicated, "chlorine-free detergents should be used, because they are less harmful to the environment." They did not address the reason why chlorine can be harmful to the environment."



3.2. Raise possible explanations – hypotheses – regarding the environmental harmfulness of the chemicals identified in the previous question.

Use chlorine-free detergents because they are harmful for the environment

Figure 3: Example for developing hypotheses, with teacher comments on left side

In the example shown in Figure 4, the teacher comment states that "the information is not understood. The students do not relate what they write with the information provided, and they do not relate it to the problem. The students showed difficulties in interpreting the information gathered in the search, which led to the description of inaccurate conceptions."

3.2. Levantem possíveis explicações – hipóteses – dos produtos químicos identificados na questão anterior serem nocivos para o ambiente.

Nota:
A informação não está completa. Não relatou o que se sabe com a informação fornecida. Não relatou com o problema.

3.3. Planeiem uma atividade que sirva de alternativa ao problema.

11/17 CR/15: Tem ideia, mas não sabe qual é a resposta.

Resposta do aluno:
A água é um produto de limpeza a base de cloro além de ser cancerígena, tem a capacidade de se acumular na cadeia alimentar.

Resposta do aluno:
Tentar fazer um detergente ecológico.

3.2. Raise possible explanations – hypotheses – regarding the environmental harmfulness of the chemicals identified in the previous question.
The bleach is chlorine based cleaning product, besides being carcinogen has the ability to accumulate in the food chain.

3.3. Plan an activity that serves as alternative to the problem.
Trying to make an environmentally friendly detergent.
Materials: water, blue and white soap and juice (lemon).

Figure 4: Example for developing hypotheses, with teacher comments on left side

(v) Use of assessment data

The search for information should first be selected and suited to the students' knowledge, for example by suggesting websites. The feedback needed to identify the students' difficulties has to be given during the task performance.

The assessment criteria must be carefully analysed and developed in order to provide a clear guidance for students regarding what is expected. Before applying the task it is very important to try to anticipate the students difficulties, and try to think about strategies that would help them to overcome their difficulties.

(vi) Advice for teachers implementing the unit

- Regarding the search for information, it is important to select the appropriate information for students to work with (contributing to a guided internet search);
- Assessment criteria should be previously analysed and there should be an explicit disclosure of what is to be expected from students. They should have full knowledge of what the teacher is assessing.
- Students' difficulties should be anticipated and strategies to help them overcome their difficulties should be considered.
- Students should be heard regarding self-assessment, and difficulties should be identified.
- Continuity should be given to the aspects where students show difficulties, particularly regarding the skills that are not satisfactorily developed.