

4.3 Case study 3 (CS3 Hungary)

Concept focus	Behaviour of oil in water Environmental impact of oil spills
Inquiry skills	Planning investigations Developing hypotheses Working collaboratively
Scientific reasoning and literacy	Not assessed
Assessment methods	Classroom dialogue Teacher observation Worksheets Student devised materials (photographs of investigations)
Student group	Grade: 9 th grade (upper second level) Age: 15-16 years Group composition: mixed ability and gender; 20 students Prior experience with inquiry: Yes, very experienced with inquiry

This case study details a *bounded inquiry* activity; following a whole-class and group discussions, student groups planned investigations and carried them out. The skills assessed were *planning investigations*, *developing hypotheses* and *working collaboratively*. For *planning investigations*, the groups were given grades based on their worksheets. Students' skills in *working collaboratively* (cooperation, participation) and *developing hypotheses* (research questions) were also assessed though teacher observation using a scoring rubric.

(i) How was the learning sequence adapted?

The **Black tide – oil in the water** SAILS unit was implemented in as suggested in the unit, using a *bounded inquiry* approach. The topic was discussed partly as a whole class and partly in groups in one 45-minute lesson and a double lesson of 90 minutes. The inquiry activity was implemented in connection with the formation and use of sedimentary rocks, their mining and the environmental effects of transportation in geography. When the environmental effects and consequences of major oil disasters were discussed, we looked up the site of the Exxon Valdez disaster in an atlas and the students studied the map showing the spread of the oil patch. As a whole class, we discussed the consequences of such an accident for life in the sea and human settlements along the affected coastline. Students used their prior knowledge to complete the task.

Taking the questions that came up as their starting point, the students investigated how the oil could have spread in the bay. The inquiry task was carried out in groups of four students, of mixed ability. The questions on the student worksheet were left unmodified and the groups worked on the sheets following a pre-given structure:

- Their first task was to design the experiment exploring the behaviour of oil in the ocean. The equipment and materials listed on the sheet could be used in the experimental plan. The students mixed the cocoa and the oil themselves using the ratios given.
- The independent variables were examined next: e.g. the effect of ocean currents on the spreading rate of the oil.
- The students then described what they thought would happen.
- After consulting with the teacher, they carried out the experiment.

When planning the experiments, the students kept in mind that they were working with seawater but they forgot about this fact during the implementation. The first group to have their plan ready carried out the experiment and were surprised to discover that the oil sank to the bottom of the

water. They tried to think of an explanation. They very quickly realised that they were working with tap water rather than “seawater.” They looked up the salt content of seawater on their smartphones and asked for a digital balance, measuring cups and salt to make the salt solution. Learning from this experience, the remaining groups worked with salt water from the beginning.

One group had the problem that they had forgotten to time the spreading of the oil but they found a creative solution because they had recorded the spreading of the oil on their phones so they could time it in the recording.

The groups shared their experiences with each other at the end of the second lesson.

(ii) Which skills were to be assessed?

The skills assessed in this case study were *planning investigations*, *developing hypotheses* and *working collaboratively*. The groups were given grades based on the collected worksheets and the photographs they submitted to the teacher, i.e. this assessment focused on the planning and implementation of the investigation. Students’ skills in *working collaboratively* (cooperation, participation) and *developing hypotheses* (research questions) were also observed and assessed using the scoring rubric as a guide (Table 1).

During the activity, the teacher guided the students with facilitating questions. This was especially important for students with emotional behavioural difficulties or with special educational needs. The two groups of girls needed the teacher to regularly reinforce their ideas while they were doing the experiment. The teacher used the mirror method with them: “You think that...” or “So you...” The teacher observed that girls’ questions tended to seek confirmation, while boys’ questions, in contrast, took the form “we can try... can’t we?”

(iii) Criteria for judging assessment data

The students should be able to use an experiment to show how oil behaves in the ocean and to understand why the spilt oil endangers sea birds. Based on the unstructured worksheet, the students should be able to understand the task, plan the experiment, carry out the experiment and describe their experiences. That is, they should use their prior knowledge.

I used both formative and summative forms of assessment in the project. The students were familiar with this formative assessment system because we had used similar systems in other project activities. The groups were evaluated based on their scores and the finished work was graded.

Table 1: Assessment of inquiry skills in CS3 Hungary

Skill assessed	Extending	Consolidating	Developing	Emerging
Working collaboratively (participation)	Always participates in the work and works on the task throughout the class.	Mostly participates in the work and usually works on the task.	Participates in the work but does not make good use of time or spends little time on the task.	Does not participate in the work, does not make efficient use of time or is occupied with something other than the task.
Working collaboratively (cooperation)	Treats others with respect and shares responsibilities.	Usually treats others with respect and shares responsibilities.	Sometimes lacks respect in interacting with others.	Often lacks respect in interacting with others.
Developing hypotheses (research question)	The research question is precise and detailed.	The research question is unambiguous.	The research question is somewhat incomplete.	The research question or its formulation is incomplete or incorrect.
Planning investigations (inquiry process)	<p>The research design is appropriately constructed based on the hypothesis; the experiment gives a complete answer to the research question.</p> <p>The individual steps of the experiment are described accurately.</p> <p>The independent and dependent variables are correctly identified.</p>	<p>The research design is reasonably constructed based on the hypothesis; the experiment gives an answer to the research question.</p> <p>The steps of the experiment are described.</p> <p>Most independent and dependent variables are identified.</p>	<p>The research design is incorrectly constructed based on the hypothesis; there are mistakes in the hypothesis.</p> <p>Some steps of the experiment are described but some crucial details are omitted.</p> <p>Some independent and dependent variables are identified.</p>	<p>The research design is not related to the hypothesis or contains serious mistakes.</p> <p>There are fundamental problems with the experimental procedure.</p> <p>Dependent and independent variables are not identified.</p>

(iv) Evidence collected

Teacher's opinion

The students enjoyed this activity – as they do every activity involving action. Every group worked actively. Even students who are usually less active during experiments had the confidence to participate.

The students at first had difficulty identifying the dependent and independent variables, and did not realise that it is best to change only one thing at a time when doing experiments, so that they could measure the effects. I asked facilitating questions: “Which variables can be measured? What is the purpose of the experiment? How can we plan a measurement?” Unfortunately, the research question was not quite perfect. The students have a lot to learn in this respect. The steps of the experiment were successfully recorded by all but one group. This group also carried out the experiment but they didn't have steps through which to organise the information. The students had no difficulty assembling and carrying out the experiment but they didn't find the task of keeping written records of their steps and experiences very “exciting.”

I find the activity good, but as an unstructured activity it is only suitable for students and groups who can confidently run an investigation and are familiar with methods of inquiry learning. My experience is that the activity also requires a degree of confidence and familiarity with the method of inquiry learning from the teacher. If these skills are not available, it is better to convert the activity into a structured one. Both the students and the teacher will have a more positive experience that way. The scoring rubric is of great help to the teacher in assessment, especially if they have a large group of students or wish to track the progress of the students.

Sample student artefacts

Evidence collected by the teacher include student worksheets, photographs of the experiments in progress and a video recording. Some examples of student work are shown in Figure 1 to Figure 6. The teacher observed that a typical mistake involved the choice of dependent and independent variables. The students needed assistance, but the guiding questions finally led the groups to the correct solutions. One group was well aware that the oil was poured in the sea but they did not find salt water naturally so they used tap water instead. Later, when they were trying to identify mistakes, they realised which step they had got wrong. They carried out two experiments: in one they reduced the quantity of cocoa to find out what would happen and in the other one the original ratio of cocoa and oil was used.

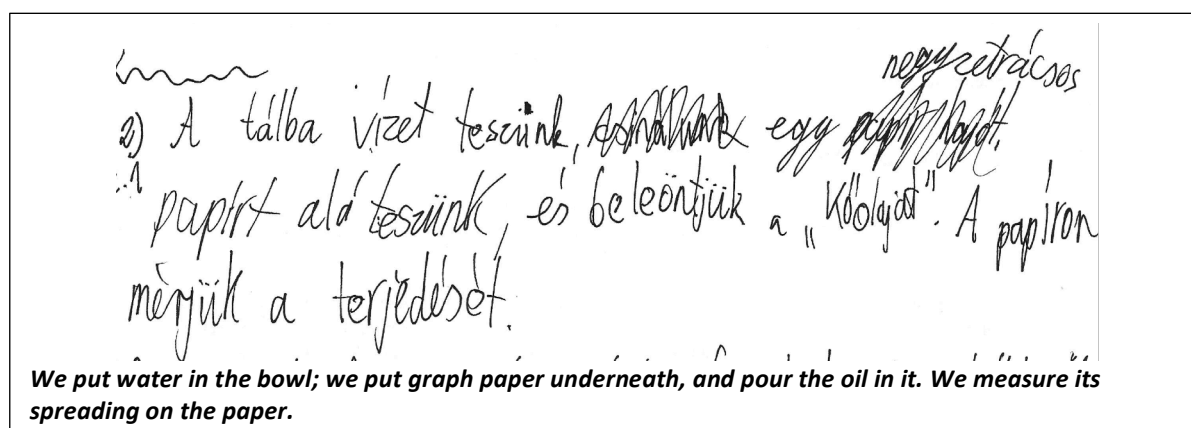


Figure 1: Example of planning an investigation

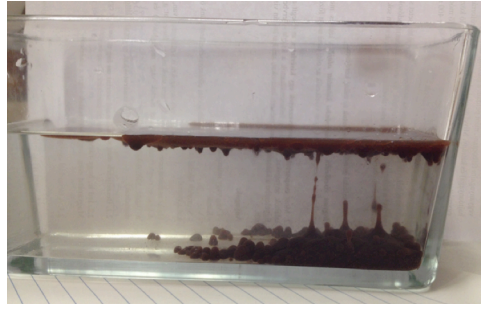


Figure 2: Images of experiments looking at independent variables

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- Az olaj nagy része masszíven leáll az üveg aljára. A víz
felületén keheketnyi olajréteg maradt.
"Szél" és vízmozgás hatására terjed a tálban (nagyon kicsit)
Ha valami átsiklik a vízen/vízben az olaj vastagon
rakódik.

Most of the oil settles at the bottom of the bowl. Only a thin layer stays on the surface of the water. It spreads in the bowl by "wind" and water currents (only very little). When something glides across/through the water, a thick layer of oil settles on it.

Figure 3: Investigation of oil in fresh water (unsalted)



5) Egészen más történt, mint amit vártunk, így nehéz összerakni a kettőt.

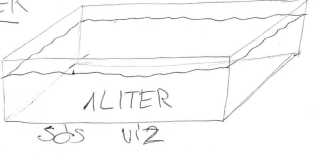
ahogy gondoltuk	ahogy történt
foszékony állagú kólaaj marad	összeállt a kólaaj
víz felszínén lebeg	lesüllyedt a víz alá
terjedés kis idő	terjedés sok idő

We had a completely different result from what we'd expected, so it's difficult to compare the two.

What we'd thought:	What happened:
oil remains liquid	oil condensed
it floats on the surface of the water,	it sank to the bottom of the water
it spreads in a short time	spreading took a long time

Figure 4: Example of student recording of observations

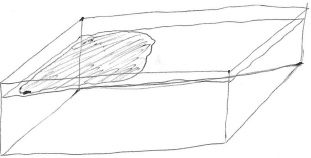
TERVEK



kólaaj: kakaópor: 6 púpos ek
olaj: 17-18 ek (minél nagyobb)

sóoldat: 1 liter víz
35 gramm só

Azt szeretnénk bizonyítani, hogy az olaj fenn marad a víz felszínén, és terjed.



30 ml olaj 1 perc alatt 328 cm² területre terjedt el.

Minden a várakozásaink szerint történt.

1 LITRE SALT WATER

**Oil: 6 tbsp. cocoa,
17-17 tbsp. oil,
Salt solution: 1 litre water, 35 g salt**

We would like to show that the oil floats on the surface of the water and spreads.

90 ml oil spreads to an area of 328cm² in 1 minute.

Everything happened as we'd expected.

Figure 5: Investigation using salt water, after modification of method

Mit várunk?

1. LEPERGETI A VÍZET, FENNMARAD
2. VÍZES LESZ ÉS LEMEGY
3. ÚJRA LEBEG

EREDMÉNY:

1. NEM ^{MERT} LE A VÍZ ALÁ, VÍZES SEM LÉTT
2. BEERAGADT AZ OLAJBA, SÚLYOSAN ATÁZOTT
3. ELŐSZÖR FENNMARADT, DE EGY KIS NYOMÁSRA LE-
SÜLLT (VALÓSZÍNŰLEG MEG KELLT VÖLNASZÁRTANI)

What we expect:

- 1 in clean water it repels the water and floats,
- 2 in oily water it gets wet and goes down,
- 3 when cleaned it floats again.

Results:

- 1 in clean water it did not go under the water and didn't get wet,
2. In oily water it stuck to the oil and became soaking wet,
3. When cleaned it first floated but sank under a little pressure (we should probably have dried it)

Figure 6: Investigating the effect of oil on the feathers of birds

(v) Use of assessment data

We discussed our experiences during the next class period, the students shared their videos on Facebook and everybody could look at the work of the other groups. I pointed out the correct and accurate solutions.

In this school year this class will have two more inquiry activities. It is important to foster their inquiry skills (accurate recording of information, formulating questions and research questions, describing relationships and written work) and their environmental awareness.

(vi) Advice for teachers implementing the unit

As I mentioned before, for a teacher less familiar with inquiry learning it would be best to use a structured worksheet as the basis of the activity and unstructured problem solving should only be used at certain steps. The task allows the development of several skills and provides a variety of possible working methods for teachers.