4.4 Case study 4 (CS4 Poland)

Concept focus	What affects the behaviour of objects in water?
Inquiry skills	Developing hypotheses Planning investigations Forming coherent arguments Working collaboratively
Scientific reasoning and literacy	Not assessed
Assessment methods	Classroom dialogue Teacher observation Worksheets
Student group A	**Grade:** lower second level **Age:** 13 years **Group composition:** co-ed class (8 girls, 4 boys), groups of 4 (student-selected, single gender and mixed ability) **Prior experience with inquiry:** Yes, some prior experience. Students had up to 7 hours of guided inquiry activities on basic measurements in physics, gravity, density and how to find the centre of mass
Student group B	**Grade:** lower second level, workshop for home-schooled children **Age:** 10-13 years **Group composition:** co-ed class (5 girls, 10 boys), groups of 5 (student-selected, single gender and mixed ability) **Prior experience with inquiry:** Yes, some prior experience (as above).

This case study details implementation with two lower second level classes, one of which was a workshop for home-schooled children. The teacher provided a detailed worksheet to guide the students' inquiry. All four SAILS inquiry skills were assessed; students' skills in carrying out an investigation and *working collaboratively* were assessed through classroom dialogue and teacher observation in-class, while *developing hypotheses*; *planning investigations* and *forming coherent arguments* were assessed through evaluation of student artefacts after the lesson.

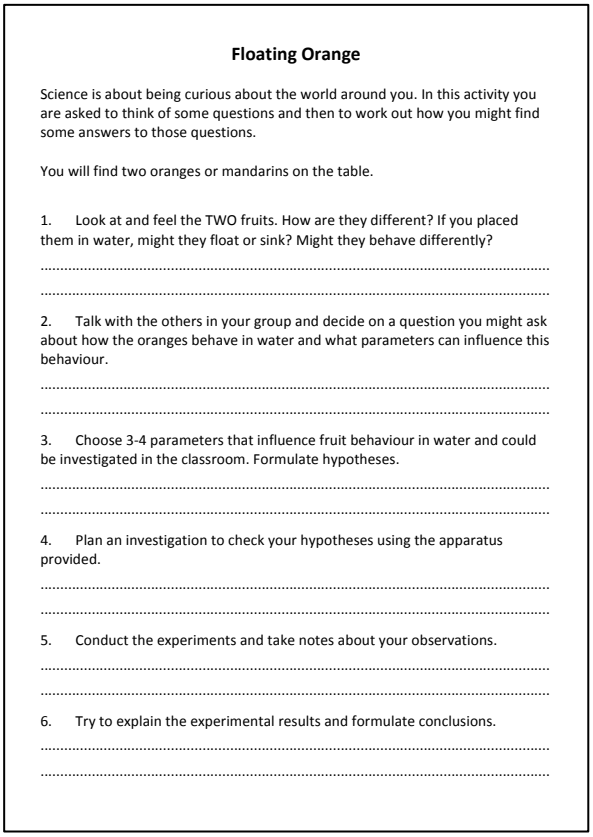
(i) How was the learning sequence adapted?

The **Oranges** SAILS inquiry and assessment unit was implemented in two classes over a one-hour lesson period each. The teacher made a minor change to the unit, and provided an extended worksheet, with 6 questions, for all students (Figure 1). There were two reasons for this change; first of all, this *guided approach* allowed students to more easily put their thoughts together and organise their notes, while secondly, the teacher wanted to gather evidence in a consistent format from all students. In each class, two groups worked with oranges and one group worked with mandarins. In addition to fruits, students could choose a limited number of objects from their own surrounding for the first activity regarding *developing hypotheses* about floating objects.

Lesson sequence

1. The introductory question was about putting forward hypotheses about objects' behaviour in water, using oranges and mandarins, as well as other objects from their surroundings that could be chosen freely. This took about 5 minutes.
2. The second question was about raising scientific questions on how different conditions can influence the behaviour of the orange/mandarin in water and about changes that could be made to alter this behaviour. This part lasted approximately 10 minutes.

3. Subsequently, groups were supposed to discuss all the ideas about scientific questions and jointly choose four parameters/conditions that could be controlled and changed in the classroom during the experiment, in order to investigate their influence on an orange/mandarin behaviour in water (question 3). The investigation plan needed to be written down (question 4). This took approximately 10 minutes as well.
4. Afterwards, investigation was carried out in groups and the observations were supposed to be collected and noted in a worksheet. This part however engaged the students so much that most of them forgot to take the notes. At this time they were very active and involved emotionally, both if their hypothesis was confirmed or disproven. This was the longest part of the lesson, which lasted around 25 minutes.
5. At the end of the activity, the final question asked students to explain their experimental results and form conclusions. It took approximately 5 minutes. The last 5 minutes of the lesson was devoted to clean-up.



Floating Orange

Science is about being curious about the world around you. In this activity you are asked to think of some questions and then to work out how you might find some answers to those questions.

You will find two oranges or mandarins on the table.

1. Look at and feel the TWO fruits. How are they different? If you placed them in water, might they float or sink? Might they behave differently?

.....

.....

2. Talk with the others in your group and decide on a question you might ask about how the oranges behave in water and what parameters can influence this behaviour.

.....

.....

3. Choose 3-4 parameters that influence fruit behaviour in water and could be investigated in the classroom. Formulate hypotheses.

.....

.....

4. Plan an investigation to check your hypotheses using the apparatus provided.

.....

.....

5. Conduct the experiments and take notes about your observations.

.....

.....

6. Try to explain the experimental results and formulate conclusions.

.....

.....

Figure 1: Student worksheet

(ii) Which skills were to be assessed?

In this implementation, the teacher chose to assess the four SAILS inquiry skills – *developing hypotheses*, *planning investigations* (including implementation), *forming coherent arguments* and *working collaboratively*. The teacher assessed work both on the basis of in-class observation during the lesson and evaluation of students' worksheets after the lessons.

Skills to be assessed through evaluation of students' worksheets were:

- Raising scientific questions
- Planning an investigation
- Forming coherent arguments

Skills to be assessed through teacher observation in-class:

- Conducting an experiment
- Working collaboratively

In this implementation, the teacher did not plan to address any gender issues. However it was observed that the student-selected groups were single-sex teams in both classes. During the investigation, groups competed with each other and stronger competition could be observed between groups of different sex. The teacher had to admonish the groups, once or twice, so as they did not show each other respect.

After analysis of worksheets, the teacher observed that in general girls performed better than boys in formulating notes in a clear, grammatically correct way in both the regular class and the home-schooled group. The girls also took more time to take more elaborated notes than boys.

For in-class assessment, a rubric was utilised to assess *working collaboratively* at the whole group level when observing students' behaviour during investigation in the classroom. The same rubric method was used after the lesson to assess students' performance on the basis of their worksheets. The skill of *forming coherent arguments* was evaluated for each learner individually. *Developing hypotheses* (raising scientific questions) was both individual and collaborative work, so the teacher assessed it individually and on the group level. Individual assessment was based on answers to question 2 in the worksheet (deciding on questions about how organs behave in water, and what parameters affect this) and assessment at the group level was achieved through evaluation of question 3 (choose 3-4 parameters to investigate and formulate hypotheses). *Planning investigations* was a collaborative task and the teacher assessed at group level for this skill. Written feedback was provided to the students.

(iii) Criteria for judging assessment data

The teacher clearly defined the success criteria for each of the skills to be assessed, as detailed below. All assessment tools used during implementation of this unit allowed for formative assessment of the students' performance. No summative assessment has been proposed.

Developing hypotheses (raising scientific questions)

The response was satisfactory when it was evident that students contributed to the group work, by listing at least four research questions of their own, that could develop into at least one research question at group level. The questions should be possible to investigate in the classroom.

Planning investigations

A satisfactory level was achieved when the group could agree what to do in order to change a parameter or a condition that would allow observation of the alteration of orange/mandarin behaviour in water. This should be elaborated for all research questions.

Forming coherent arguments

An excellent level would be achieved when students could explain all the results using scientific arguments. A satisfactory level is coherent argumentation in explaining at least one result out of four.

Conducting an experiment and working collaboratively

Those two skills were assessed at the same time, during in-class teacher observation of particular groups. The teacher used the proposed rubric from the original unit for evaluation of performance. The performance was satisfactory if the learners worked as a team, listened to each other and did

not show disrespect to others' ideas. A joint agreement on a set of four research questions, and collaborative work involving all members of the group during their investigation was essential for satisfactory level of performance.

(iv) Evidence collected

Teacher's opinion

The students enjoyed the activity very much. It was fascinating to see most of them totally engaged in all parts of the lesson, starting from *developing hypotheses* and ending at conducting the experiment. They worked hard not only on hands-on experiments, but also did preparatory work well and took satisfactory notes.

Most of the students performed well regarding the involvement and carrying on the experiment. However it can be noticed that in general they have minor or major problems with formulating notes useful for communication with others.

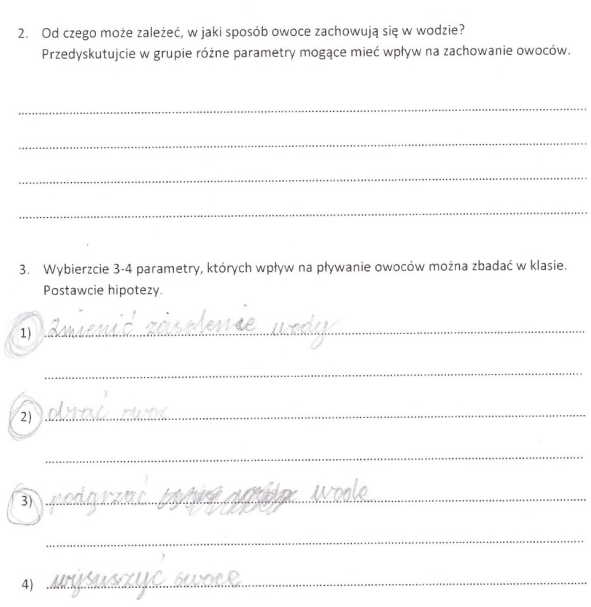
Only small differences have been detected between the regular class and the group of home-schooled children. In both, the weakest skill was that of *forming coherent arguments* and drawing the conclusions. The vast majority of the home-schoolers and most of the students from the regular class either left it blank or replaced it with notes about the course of investigation. This proved that learners did not have a clear idea about this part of the activity and were not used to do that. It may also be true that more time should be devoted at this point of the lesson.

The time anticipated for activity was not enough. The teacher would suggest devoting 80-90 minutes to this unit, rather than 60 minutes, in order to have enough time to perform the investigation without hurrying and to complete the last part of the activity, especially in case of classes less experienced with IBSE. The activity seemed very easy, but in the course of the lesson it occurred to be quite demanding, but at the same time it engaged the students very much.

Sample student artefacts

Developing hypotheses (raising scientific questions)

The first example is from a student in the home-schooled students' workshop (Figure 3). This student did not mention any parameters in question 2, which was used to assess individual contribution to this skill. His group chose four investigative parameters, as detailed in the response to question 3. This student was identified as an example of performance at the emerging level.


2. Od czego może zależeć, w jaki sposób owoce zachowują się w wodzie? Przedyskutujcie w grupie różne parametry mogące mieć wpływ na zachowanie owoców.

3. Wybierzcie 3-4 parametry, których wpływ na pływanie owoców można zbadać w klasie. Postawcie hipotezy.

1) zmienić zasolenie wody

2) obrać owoc

3) podgrzać wodę

4) wyciskać owoce

2. Talk with the others in your group and decide on a question you might ask about how the oranges behave in water and what parameters can influence this behaviour.

3. Choose 3-4 parameters that influence fruit behaviour in water and could be investigated in the classroom. Formulate hypotheses.

1)...***change water salinity***.....

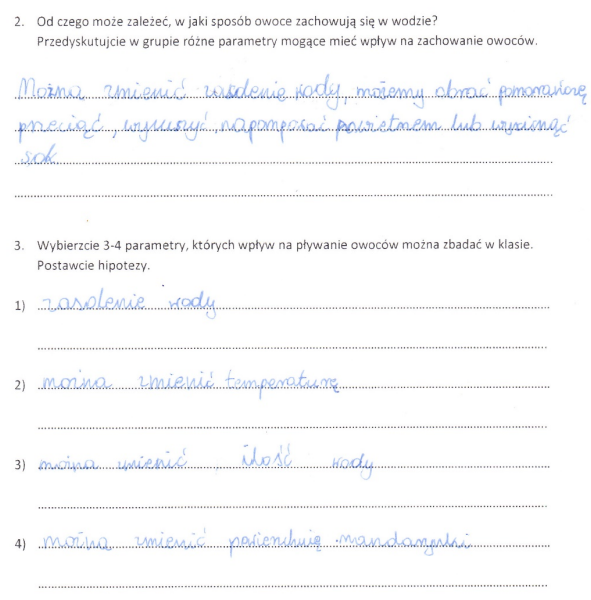
2)....***peel the fruit***.....

3)....***heat water***.....

4)...***dry fruits***.....

Figure 2: Example of developing hypotheses (emerging level)

A second example from the home-schooled children's workshop is shown in Figure 3. Here, the student mentions different parameters in question 2 and the group chose four investigative parameters in question 3. This was assigned a performance level of "satisfactory."


2. Od czego może zależeć, w jaki sposób owoce zachowują się w wodzie? Przedyskutujcie w grupie różne parametry mogące mieć wpływ na zachowanie owoców.

Można zmienić zasolenie wody, możemy obrać pomarańczę, pociąć, wysuszyć, napompować powietrzem lub wycisnąć sok

3. Wybierzcie 3-4 parametry, których wpływ na pływanie owoców można zbadać w klasie. Postawcie hipotezy.

1) zasolenie wody

2) można zmienić temperaturę

3) można zmienić ilość wody

4) można zmienić powierzchnię mandarynki

2. Talk with the others in your group and decide on a question you might ask about how the oranges behave in water and what parameters can influence this behaviour.

.....***One can change the salinity level, we may peel the orange, cut, dry out, pump with air, or squeeze***.....

3. Choose 3-4 parameters that influence fruit behaviour in water and could be investigated in the classroom. Formulate hypotheses.

1)... ***salinity***.....

2)....***one may change the water temperature***.....

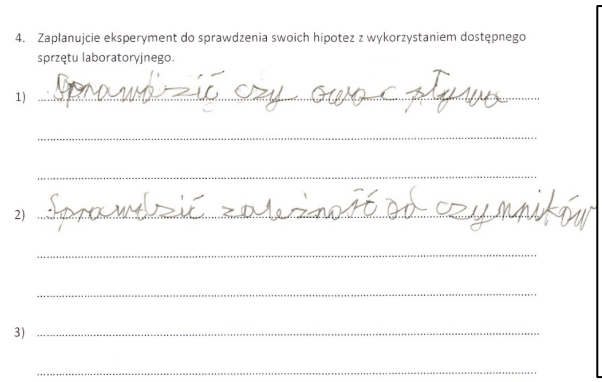
3)....***one may change the quantity of water***.....

4)...***one may change the mandarin surface***.....

Figure 3: Example of developing hypotheses (satisfactory level)

Planning investigations

In the first example for *planning investigations*, a student in the workshop for home-schooled children mentions two steps of the investigation plan in a very general way. This was assigned a performance level of "emerging."


4. Zaplanujcie eksperyment do sprawdzenia swoich hipotez z wykorzystaniem dostępnego sprzętu laboratoryjnego.

1) Sprawdzić czy owoc pływa

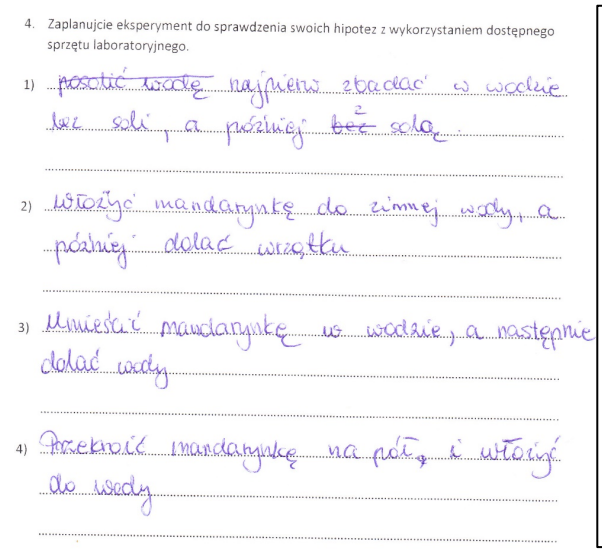
2) Sprawdzić zależność od czynników

3)

4. Plan an investigation to check your hypotheses using the apparatus provided.
1)...***check if the fruit floats***.....
.....
.....
2)....***investigate the influence of different***.....
parameters.....
.....
3).....
.....
.....

Figure 4: Example of planning investigations (emerging level)

An example of student performance at a satisfactory level is shown in Figure 5. This student, from the home-schooling workshop, mentions alteration of four different parameters but is not precise about the amounts.


4. Zaplanujcie eksperyment do sprawdzenia swoich hipotez z wykorzystaniem dostępnego sprzętu laboratoryjnego.

1) postić wodę najpierw zbadać w wodzie bez soli, a później ~~bez~~ z solą

2) włożyć mandarynkę do zimnej wody, a później dolać wrzątku

3) Umieścić mandarynkę w wodzie, a następnie dolać wody

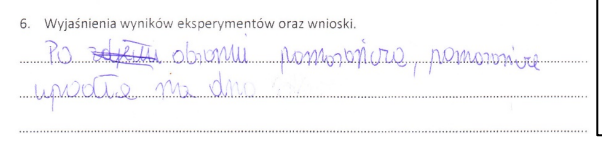
4) Przekroić mandarynkę na pół, i włożyć do wody

4. Plan an investigation to check your hypotheses using the apparatus provided.
1)...***first check in tap water, then in salted water***..
.....
.....
2)....***put a mandarin in cold water, add boiling***.....
...***water later***.....
.....
3)....***put a mandarin in water, add more water***.....
.....
.....
4)....***cut a mandarin in half and put in water***.....
.....
.....
.....

Figure 5: Example of planning investigations (satisfactory level)

Forming coherent arguments

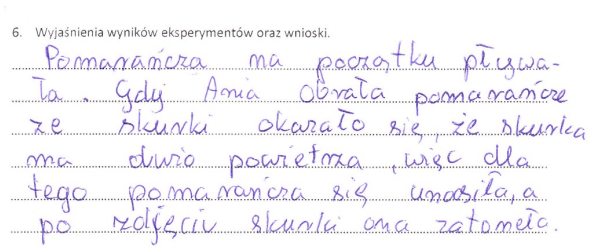
Assessment of this skill was carried out by evaluating student responses to the final question on the worksheet: "Try to explain the experimental results and formulate conclusions." An example of student performance at the emerging level is shown in Figure 6, while Figure 7 shows performance at a satisfactory level.


6. Wyjaśnienia wyników eksperymentów oraz wnioski.

Po ~~zdjęciu~~ obraniu pomarańcza pomarańcz upadła na dno

6. Try to explain the experimental results and formulate conclusions.
..***After peeling an orange it falls to the bottom***.....
.....

Figure 6: Example of forming coherent arguments (emerging level)


6. Wyjaśnienia wyników eksperymentów oraz wnioski.

Pomarańcza na początku pływa-
ła. Gdy Ania obrała pomarańcze
ze skórki okazało się, że skórka
ma dużo powietrza, więc dla
tego pomarańcza się unosiła, a
po zdjęciu skórki ona zatonęła.

6. Try to explain the experimental results and formulate conclusions.

...***peeling an orange made it sink because the skin contains a lot of air, which normally makes the orange float***.....

.....

.....

Figure 7: Example of forming coherent arguments (satisfactory level)

(v) Use of assessment data

Written feedback as given to each student on the basis of their worksheets. The teacher decided to repeat such activities in order to develop a research attitude in students and to improve their performance and level up their inquiry skills.

(vi) Advice for teachers implementing this unit

Teachers implementing this unit need to allocate enough time for the activity. Before implementation, the teacher should carefully think over the possible ideas for investigation that may occur in the classroom and try to provide sufficient equipment in the classroom, to avoid surprises during the lesson.