

4.1 Case study 1 (CS1 Germany)

Concept focus	Understanding floating and density
Inquiry skills	Planning investigations Working collaboratively
Scientific reasoning and literacy	Not assessed
Assessment methods	Classroom dialogue Self-assessment Student devised materials (reports)
Student group	Grade: lower second level physics class Age: 13-14 years Group composition: mixed gender and ability, groups of 3-4 (24 students) Prior experience with inquiry: Yes, some prior experience

Students investigated the floating behaviour of citrus fruits – oranges, lemons and limes – while developing their skills in *planning investigations* and *working collaboratively*. The teacher used the “fist to five” method to ensure students understood the task, and “traffic light cups” to ensure directed guidance during the lesson. Assessment methods included classroom dialogue and self-assessment, as well as evaluation of student artefacts.

(i) How was the learning sequence adapted?

The **Oranges** SAILS inquiry and assessment unit was trialled in a normal physics lesson. As the concept of density is not part of the physics curriculum in Germany, it was taught as a special insertion into the physics lesson. Considering this circumstance, the focus of the lesson was set on process-oriented competencies *planning investigations*, carrying out an investigation and communication.

The teacher started the learning sequence with the question: “Do different citrus fruits have the same floating characteristics?” To investigate the research question, the teacher bought different citrus fruits to the lesson, such as limes, lemons and oranges. When the students put the citrus fruits into water, the lemons and oranges floated on the water surface, while the limes sank to the bottom of the beaker (Figure 1).

Additionally, a set of materials, including scales, thermometers and measuring taps, was given to the students to investigate their own hypotheses concerning the issue. The investigation was carried out in mixed gender groups of 3-4 students. After being given the research question, the students had no further instructions from the teacher on how to proceed with their investigation.

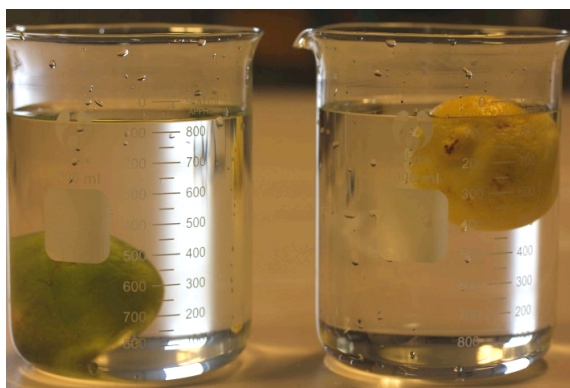


Figure 1: Lime (left) and lemon (right) in a beaker of water

(ii) Which skills were to be assessed?

The activity was used to assess students' skills in *planning investigations*, carrying out investigations and *working collaboratively* (communication). To provide feedback during the inquiry process, the teacher used different formative assessment methods:

- After posing the initial question the teacher used a method called “Fist to Five” to ask students if all understood what to do in the inquiry task. To give feedback, the students used their fingers as a scale (fist: I did not understand – five fingers: Everything is totally clear).
- During the inquiry process the teacher used a method called “traffic light cups.” This allows students to indicate their need for help during practical work by using different coloured cups (red cup: we need help urgently, yellow cup: we need help but have some time, green cup: no problems). This method facilitates focused and purposeful feedback by the teacher.
- After carrying out the investigation, students' self-assessment was carried out. The teacher adapted the rubrics so that the students could use them to reflect on the working process and the communication within their group.
- Additionally students' protocols (reports) were collected to get information about their documentation skills and the results achieved by each group.

For evaluation of student performance, the teacher used self-assessment questionnaires. These addressed three aspects of the inquiry process – communication, work attitude, and engagement in the inquiry process. The students' self-assessment showed that, in general, the students rated their own group communication and the group work very positively (Table 1, Table 2 and Table 3).

Table 1: Self-assessment of communication skills

Behaviour	I achieve this goal totally	I achieve this goal partly	I don't achieve this goal
1. I let my schoolmates finish their arguments and did not disrupt them.	17	7	0
2. I did not make inappropriate comments in response to my schoolmates' arguments.	19	5	0
3. I did not put my schoolmates under pressure or force them to do what I wanted.	23	1	0
4. I informed all group members about the planned investigations or upcoming inquiry processes.	18	6	0

Table 2: Self-assessment of work attitude

Behaviour	Always	Almost always	Sometimes	Almost never	Never
1. I concentrated on the task					
2. I worked autonomously					
3. I worked methodically					
4. I worked in a team					

Table 3: Self-assessment of the inquiry process

Behaviour	I agree totally	I partly agree	I disagree
1. I investigated the relationship between the floating properties of citrus fruits and temperature	0	0	24
2. I investigated if parts of the fruit show the same floating properties as the entire fruit	19	1	4
3. I investigated the relationship between the floating properties of citrus fruits and their mass	18	2	4
4. I investigated the relationship between the floating properties of citrus fruits and volume	9	4	11
5. I have determined the density of the fruits	4	6	14
6. I can describe our inquiry process	20	4	0
7. I can give reasons for our inquiry process	13	11	0

(iii) Criteria for judging assessment data

The sequence focused mainly on the inquiry skill *planning investigations*. The teacher described the following learning goals as essential:

- Students should control variables in a way that only one variable is changed between different experimental approaches,
- Students should manage to investigate at least one experimental approach,
- Students should document their investigation adequately
- Students should communicate in a way that all group members can add their ideas and suggestions
- Students should reflect on their individual working process.

To give feedback the teacher used the formative assessment methods described and tried to support students' work during the process.

(iv) Evidence collected

Teacher's opinion

The teacher described that he was surprised by the motivation and verve that the students showed when investigating the task and reported that many students told him that they enjoyed the inquiry. But he also summarised that he observed a large variance in the time that different groups needed to do their investigation. He noted that some groups completed one or two approaches, but had no idea how to raise further research questions. His conclusion was that the students are not yet accustomed to open inquiry and so they have difficulties thinking about the process as a whole. He observed as well that the students show deficiencies in keeping a clear record of the inquiry and that this might be a focus for further inquiry lessons.

The teacher reported that most students showed 4 to 5 fingers (fist to five) after the initial question. He said that he was surprised by this result and described that most of the student groups immediately began to plan and carry out their first investigations.

The use of the traffic light method did not give him much information about difficulties in the process because the green cup was commonly used but students' protocols showed that there was a variance in how systematically the groups performed their investigations and worked out different approaches to test why the limes sink and the lemons float in water.

Sample student artefacts

Figure 2 shows two examples of student protocols. The example on the left shows weakness in the systematic documentation; not all experimental approaches are documented clearly. The initial approach – “do all citrus fruits float in the same way?” – was only documented by a sketch, without explanation. Some variables like mass and waterline were only written down but not discussed. Different hypotheses or assumptions are named and documented: “Does the form affect the behaviour? The peel? The pulp?” The example on the right shows a more elaborated protocol. Different steps in the inquiry process behaviour and documented (e.g. question, experimental approach, observations, interpretation). The documentation of the observations shows that the students did their investigation very systematically, as they tabulate their data.


<p><u>Floating behaviour of citrus fruits</u> weight of lime: 64 g weight of lemon: 150 g</p>  <p>Outline:</p> <p>Lime: goes under, does not float Lemon swims, or floats</p> <p>Water level normal: 260 mL Water level + lime: 330 mL Water level + lemon: 410 mL</p> <hr/> <p>What does the lime float and the lemon not? Investigations: The form We cut the lemon. Weight now: 138 g Water level 400 mL (floats still)</p> <p>Is it the peel? The peel of the lemon is thicker. However: The peel of the lime also floats</p> <p>The pulp of the lemon sinks, lime also. However, can the flesh of the lemon hold more air</p>	<p><u>Experiment: Floating Citrus – Floating lemon</u> Material: 1 lime, 1 lemon, 2 beakers, water Task: Investigate the floating behaviour of citrus fruits</p> <p><u>Implementation:</u></p> <ul style="list-style-type: none"> • Whole lime or lemon in a beaker – fill with water. Record observations • Cut the lime or lemon, place peel and pulp in water and observe • <p><u>Observations</u></p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th></th> <th>Lime (56 g)</th> <th>Lemon (120 g)</th> </tr> </thead> <tbody> <tr> <td>Whole</td> <td>Does not float</td> <td>Floats</td> </tr> <tr> <td>Peel</td> <td>Floats</td> <td>Floats</td> </tr> <tr> <td>Pulp</td> <td>Does not float</td> <td>Does not float</td> </tr> </tbody> </table> <p><u>Evaluation: Why does the lemon float, although it is heavier than the lime?</u></p> <ul style="list-style-type: none"> • That depends on the peel. There is air in the peel of citrus fruit • However, since the air in the peel of the lime is less than that in the lemon, it sinks and the lemon floats • It could also be that there are air pockets located in the flesh of the lemon 		Lime (56 g)	Lemon (120 g)	Whole	Does not float	Floats	Peel	Floats	Floats	Pulp	Does not float	Does not float
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Figure 2: Examples of student protocols.

(v) Use of assessment data

As already reported the use of the “traffic light cups” method did not give the teacher more information of students’ needs during the inquiry process. The teacher suggests that students were not accustomed enough to the use of this method. The “fist-to-five” method gave a confirmation to the teacher not to deviate from his planned lesson sequence. The teacher’s feedback to students was only based on observations he made during the inquiry process while students were working at the task. He gave feedback to diverse ideas and experimental approaches.

The teacher has planned to give feedback on the self-assessment and the protocols. He said that he perhaps wants to pick out different aspects concerning the results of self-assessment and of the protocols (e.g. repetition of adequate communication rules in group work; accuracy in documentation). However, in general, he was pleased with the self-assessment results and the protocols and wanted to inform the students about his positive impressions of the assessment data.