4.8 Case study 8 (CS8 Hungary)

Concept focus	Density Factors that affect the floating behaviour of an object
Inquiry skills	Developing hypotheses Planning investigations Forming coherent arguments
Scientific reasoning and literacy	Scientific literacy (use of scientific language, ability to explain phenomena scientifically)
Assessment methods	Classroom dialogue Teacher observation Student devised materials (documentation of the inquiry process)
Student group	**Grade:** 6th grade, lower second level (primary school) **Age:** 11-12 years **Group composition:** groups of 4-5 (mixed gender and ability) **Prior experience with inquiry:** No prior experience, although they had conducted experiments and demonstrations and learnt to record, organise and interpret data in connection with some simple phenomena. The teacher was confident that the students were ready for inquiry learning.

The focus of this case study was development of students' communication skills, demonstrated in their use of scientific language and through the sharing and dissemination of results. Formative assessment was carried out through teacher observation and classroom dialogue, with an emphasis on communicating scientifically, while also developing skills in *planning investigations*, *developing hypotheses* and *forming coherent arguments*. The teacher found that this provided an accurate picture of students' knowledge and creativity.

(i) How was the learning sequence adapted?

The **Oranges** SAILS unit was implemented with minor modification of the structure of the student worksheet. The location of the equipment needed for measurements had to be modified slightly in order to increase usability and visibility.

The teacher strove to take the composition of each group and the characteristics of its members into consideration when giving jobs and asking questions. The questions were asked in each student's own "language." To be able to do so, the teacher had to be familiar with the children's interests and motivations. The teacher had talked to the class about inquiry learning before starting the session. They were thus looking forward to the activity with great excitement and enthusiasm. During the activity, the shared work and successful outcome were motivating forces both for the students and teacher.

(ii) Which skills were to be assessed?

The teacher wanted to test the students' communication skills and their use of scientific language with each other and with the teacher, through the sharing and dissemination of results. The teacher observed the implementation of the experiments and the recording of the results. Formative assessment was carried out through classroom dialogue, with an emphasis on communicating scientifically, while also developing skills in *planning investigations*, *developing hypotheses* and *forming coherent arguments*.

The teacher assessed the students' performance during the activity and also used the output of some of the children on completion of the activity.

(iii) Criteria for judging assessment data

The teacher identified the following indicators of student performance:

- The students were able to use the acquired scientific terminology
- The students used scientific terminology accurately
- The students identified and described a problem.
- The students asked their peers questions.
- The students asked the teacher questions.
- The students found appropriate answers.
- The students used familiar equipment.
- The students used familiar methods.
- The students recorded and organised data.
- The students presented evidence-based coherent arguments.

Students were expected to demonstrate the appropriate handling and use of equipment and measurement data, and to begin *forming coherent arguments* based on evidence. The "floating" of bodies on the surface of the water depends on the mass and volume of the object, and the ratio of these two (density).

The teacher paid special attention to the questions the children asked from each other and from the teacher. Were they successful in interpreting each other's questions and answering them or could they appropriately reformulate the questions? The teacher also noted their answers and reactions to facilitating questions. The teacher provided oral feedback on their communication skills. Their records of the results and conclusions were evaluated in writing using the grading system.

(iv) Evidence collected

Teacher's opinion

I talked to the children about the activity a week before the inquiry session. The activity took place in the framework of our monthly science laboratory held in the afternoon. They had looked forward to it with great curiosity. Their excitement and enthusiasm further intensified as they entered the lab. They inundated me with questions and I needed a lot of self-discipline not to divulge the goal of the activity to them. I tried to explain what the activity was about.

Once the groups were formed, I handed out the worksheet. The inquiry started. Both the students and I enjoyed the new situation. Both they and I felt liberated. The atmosphere was very relaxed and even the weaker students found a way to contribute ideas or participate in the data collection. Working in teams did not present any difficulty since the students had worked like that before. They quickly adopted different roles within the teams. There was no need for me to interfere.

The students worked in four separate teams. Every team had its strengths. The teams made similar progress in *planning investigations* although there were differences in pace. It seems to me that the students tried to use the experimental methods and data recording techniques learnt at previous science lab sessions. There were larger differences between the teams in *developing hypotheses*. Every team noted that mass must play a role in how much the orange sinks but they were not so sure about volume. One student made the tentative suggestion that the "floating" of the orange may have something to do with both at the same time.

Another difference between the teams was in their treatment of arguments. Two of the teams needed little help with *forming coherent arguments* and they knew why this was important. The other two teams needed more help. One of these had a lot of difficulty formulating their ideas and arguments. We needed several rounds of questions and answers before they finally succeeded.

Scientific literacy was not assessed at the group level, since the individual students' skills varied greatly. One of the students deserves special mention because he managed to describe the goal of the experiment from a scientific point of view. Most of the children tried to use scientific terminology. They also tried to use previously learnt methods of data recording. The children's diverging interests were reflected in their *scientific literacy*; it showed which field they were most interested in. They tried to approach the problems they had to solve through that field.

I had to assess the children's work using methods beyond the usual forms of evaluation. This was difficult at first because I had rarely done this before. The children are not used to receiving evaluation other than a school grade and do not know that there are other forms of feedback that can be useful to them. This novelty never became an actual problem; I just had to overcome my lack of experience.

Figure 1: Carrying out the activity.

Our experiences are mostly positive. I could present an accurate picture of their knowledge, creativity and personality to the students. I got to know them better and I hope they got to know me better. The only negative aspect was that we got very tired by the end of the activity. One of the first questions was "When do we eat the orange?" The answer was given at the end of the session (Figure 2) – in the form of action!

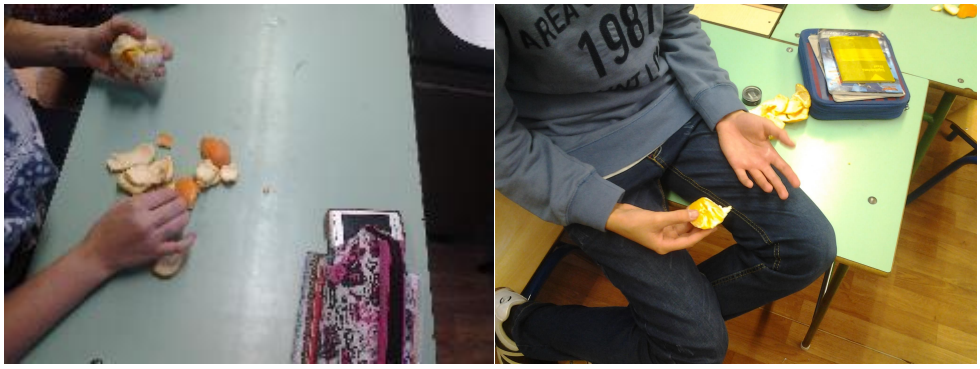


Figure 2: Having a well-earned taste of the oranges at the end of the activity!

Sample student artefacts

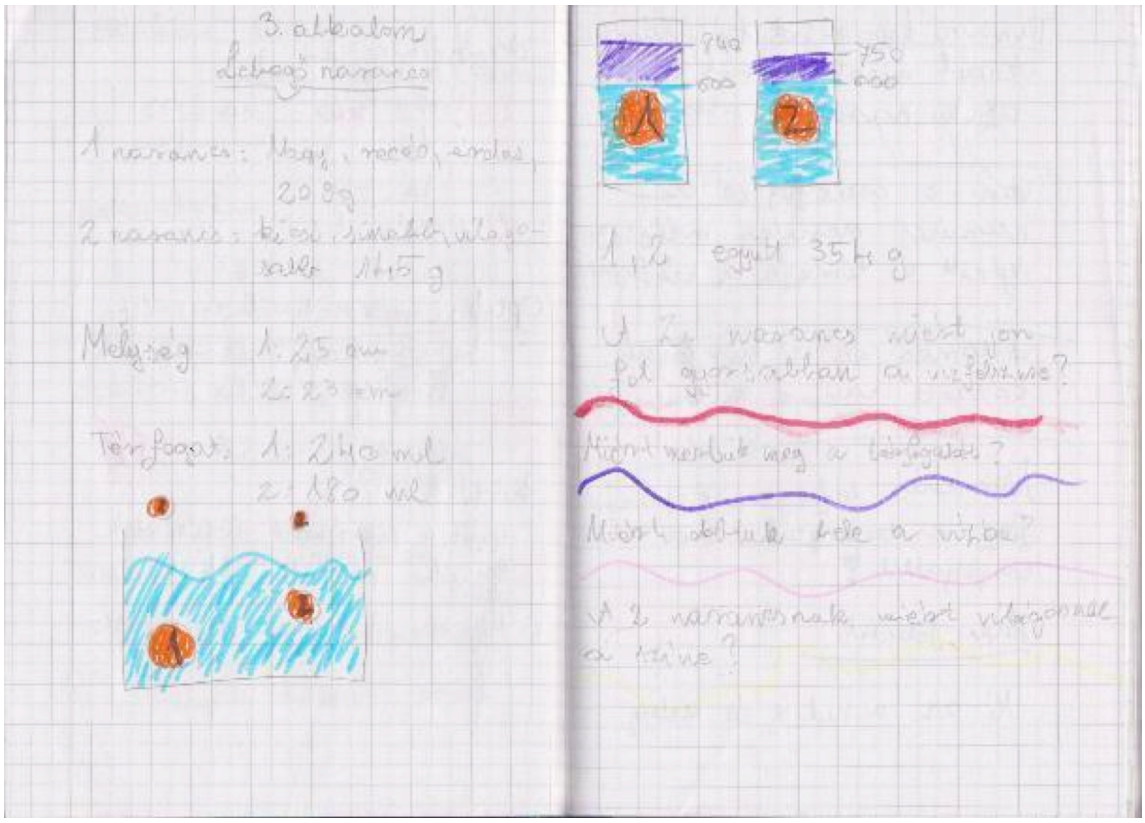
The teacher did not make any effort to have the students keep a record or transcript of the inquiry activity, only asking them to write down their results. Most of the discussion took place in speech rather than in writing. Nonetheless, the teacher collected student notebooks to gather evidence of student performance.

There was great variation in the recording of results, and documentation of the inquiry process. For example, in Figure 3 student did not tabulate the results but recorded them in an organised way, drew pictures of her observations and kept her notes organised. The appearance of her notes mattered to this student. Figure 4 provides an example of recording of the questions that arose during the class. In this case, the student wrote down the questions, but did not answer them in writing. The student recorded notes, but chose not to record his own observations, or those of his peers, because they may be incorrect. This behaviour was typical of a few of the students in the class.

In Figure 5, the student tries to describe his observations and conclusions in detail. He is a well-organised and precise student. He finds explanations for answers and formulates them in his own words.

The fourth example, shown in Figure 6, shows that the student documented the experiments in drawings. This student recorded all questions that arose during the lessons and answered them. This is the student who said something about the combination of mass and volume during the classroom dialogue. However, her description does not indicate whether she had the right idea ("say we take an iron rod or 50 feathers and it's not that the one with the larger volume will be of larger mass"). At the end of the activity, she finally found the correct relationship during the class discussion. However, she did not have time to write this final conclusion down because of having to clean up.

Further examples of student record-keeping and documentation are shown in Figure 7 to Figure 10. The teacher does not provide specific evaluation of these artefacts, but notes that some of the records appear to be incomprehensible and unusable at first sight. This may be either because of the handwriting or because of the wording. However, these children have some type of emotional, learning or behavioural difficulties. They provided oral reports of their work, their observations, questions and conclusions to the teacher, who tried to make sure that they also took some written notes.

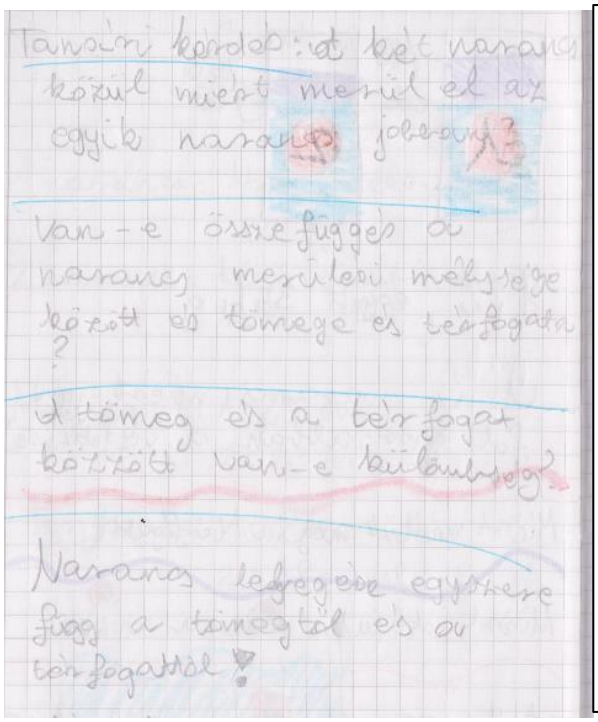


1. orange: big, reticulated, coarse, 209 g
2. orange: small, smooth, brighter, 145 g

Deepness:	*1. orange: 25 cm*
	2. orange: 23 cm
Volume:	*1. orange: 240 ml*
	2. orange: 180 ml

Why does the 2nd orange come up to the surface of the water faster?
Why did we measure the volume?
Why did we throw the orange into the water?
Why is the colour of the second orange lighter?

Figure 3: Sample from students' notebooks, example 1.



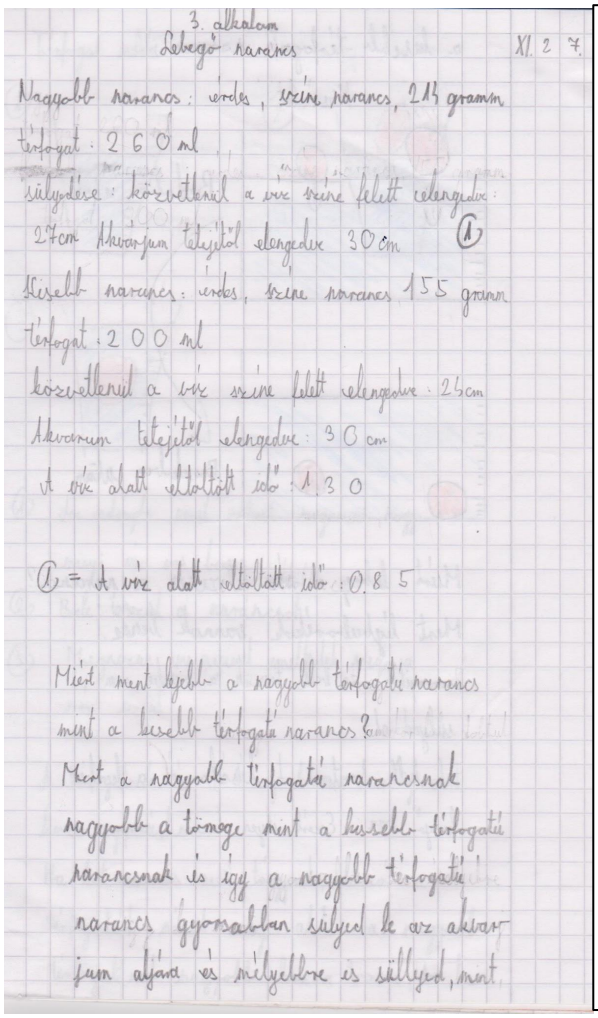
Teacher's question: Why does one orange sink better than the other one?

Is there an association between the speed of the sinking and the mass and the volume of the orange?

Is there a difference between the mass and the volume?

The floating of the orange simultaneously depends on the mass and the volume.

Figure 4: Sample from students' notebooks, example 2.



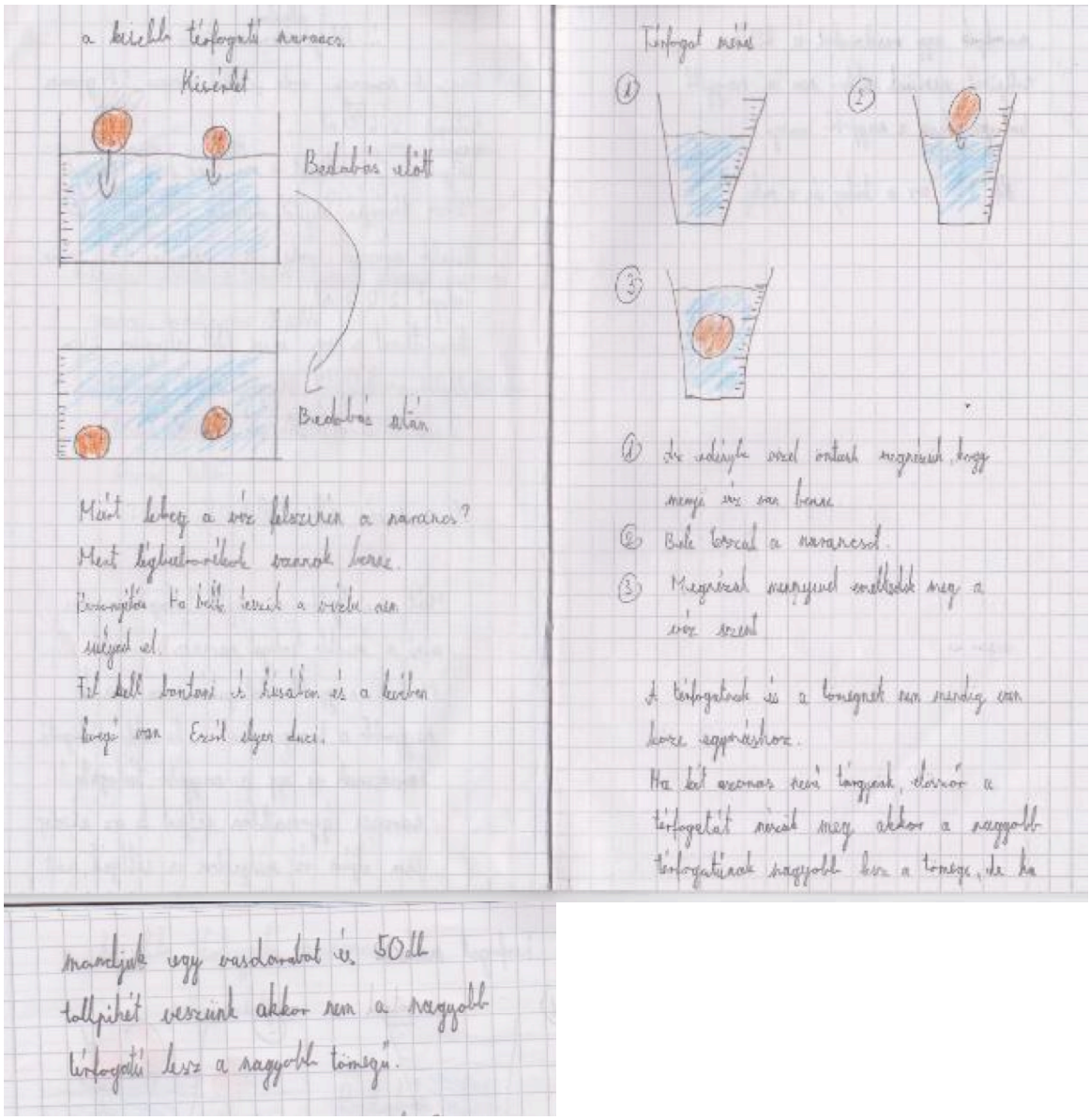
Floating orange

Bigger orange: coarse, the colour is orange, 214 g
Volume: 260 ml
Sinking: directly placing on the surface of the water – 27 cm
Placing from the top of the aquarium – 30 cm
Time spent under the water: 0.85

Smaller orange: coarse, the colour is orange, 155 g
Volume: 200 ml
Sinking: directly placing on the surface of the water – 24 cm
Placing from the top of the aquarium – 30 cm
Time spent under the water: 1.30

Why did the orange with the bigger volume sink deeper than the smaller one?
Because the orange with bigger volume has a bigger mass than the smaller one. The orange with the bigger volume sinks faster and deeper to the bottom of the aquarium.

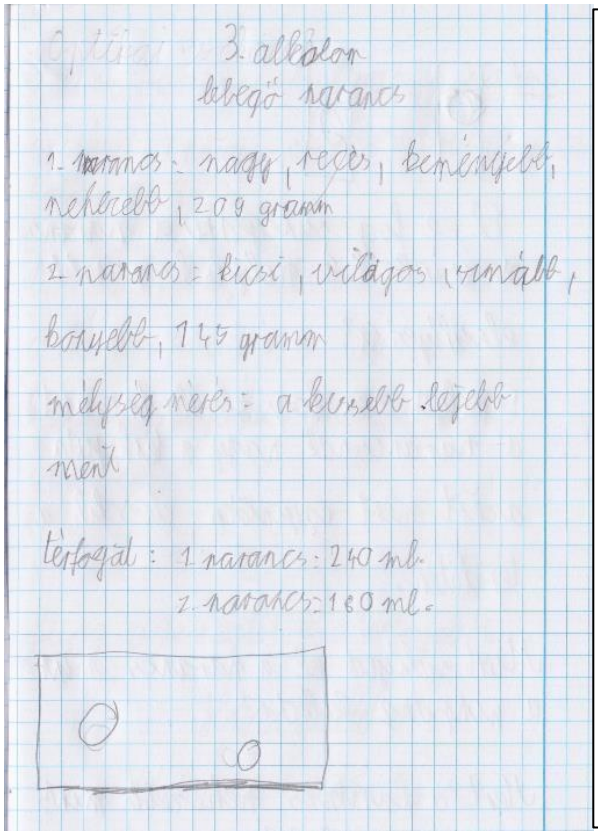
Figure 5: Sample from students' notebooks, example 3.



Why does the orange float on the surface of the water?
Because air bubbles are inside.
Proving: If we put it in the water it will not sink.
We have to peel and cut the orange, we can find air bubbles.
1. We pour water into a beaker, we measure the amount of the water.
2. We place the orange into the glass.
3. We check how the water level rises.

The volume and the mass are not always connected. If we measure the volume of two of the same objects and after that we measure the mass, then the one with the bigger volume has the bigger mass. But if we measure for example a piece of iron and 50 pieces of feather, then not the one with a bigger volume will have the bigger mass.

Figure 6: Sample from students' notebooks, example 4.



3rd occasion
floating orange

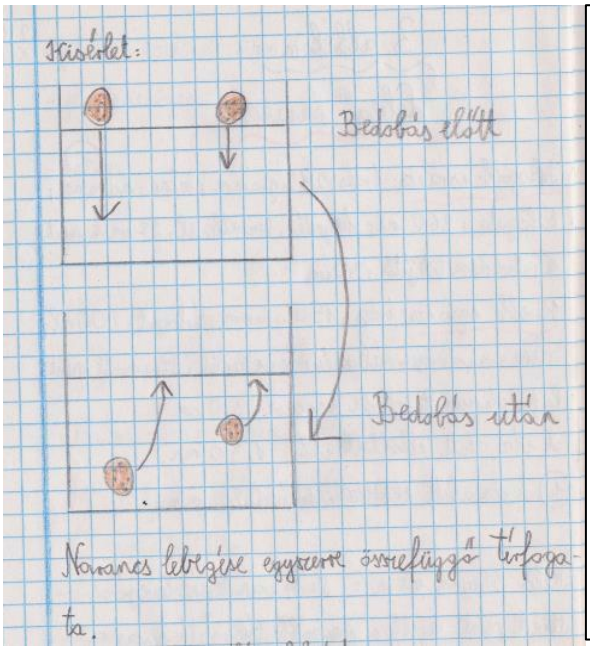
1st orange: big, knurled, tougher, heavier, 209 g

2nd orange: small, bright, smoother, lighter, 145 g

measuring of deepness: the smaller went deeper

volume: 1st orange 240 ml; 2nd orange 160 ml

Figure 7: Sample from students' notebooks, example 5.



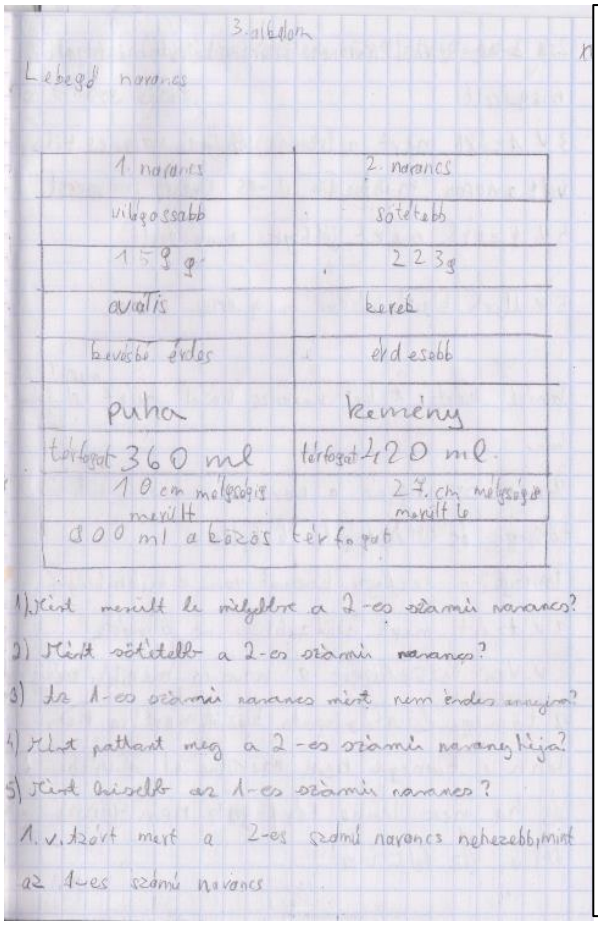
Experiment

Before throwing

After throwing

The floating of the orange depends on the volume

Figure 8: Sample from students' notebooks, example 6.



3rd occasion

Floating orange

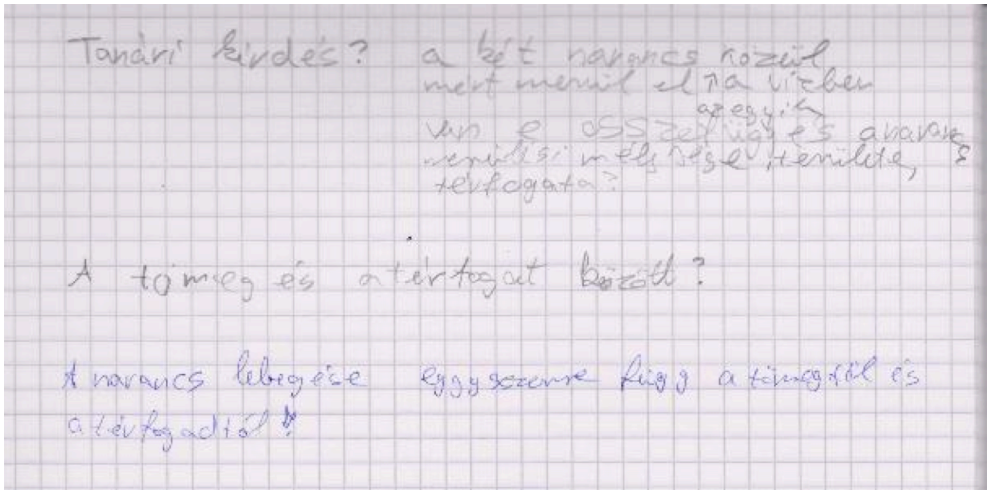
1st orange	***2nd orange***
brighter	***darker***
159 g	***223 g***
oval	***round***
less harsh	***harsher***
soft	***tough***
volume: 360 ml	***volume: 420 ml***
sinked 10 cm	***sinked 27 cm***

Common volume: 900 ml

1) Why did the 2nd orange sink deeper?
2) Why is the 2nd orange darker?
3) Why is the 1st orange smoother?
4) Why did the 2nd orange's skin deflect?
5) Why is the 1st orange smaller?

Because the 2nd orange is heavier than the 1st orange.

Figure 9: Sample from students' notebooks, example 7.



Teacher's question: why did one of the oranges sink in the water? Is there a relationship between the orange's sinking depth, the area and the volume?
Between the mass and the volume?
The floating of the orange depends on the mass and the volume at the same time.

Figure 10: Sample from students' notebooks, example 8.

(v) Use of assessment data

I gave oral feedback to the children during our next class. We discussed our experiences. The students asked to do more of these inquiry activities. I plan to turn my science lab classes into inquiry activities next year.

(vi) Advice for teachers implementing this unit

- The students must be familiar with the rules and practices of teamwork for the successful implementation of the activity.
- They must have some experience with experimental equipment.
- They must know how to record data. Data recording can follow the methods of science.
- We do not need any special lab equipment for the orange unit – the experiments can be carried out using standard kitchen equipment. The activity can even be conducted in a non-school environment.