4.3 Case study 3 (CS3 Hungary)

Concept focus	Introducing density
Inquiry skills	Developing hypotheses Planning investigations
Scientific reasoning and literacy	Scientific reasoning (collecting scientific data, recording data)
Assessment methods	Classroom dialogue Teacher observation Worksheets
Student group	**Grade:** 7th grade, lower second level **Age:** 12-13 years **Group composition:** Six groups of 4 (mixed gender and ability) **Prior experience with inquiry:** No prior experience

The teacher regularly reflected on what the groups were doing and why during the activity, and modified the implementation to better suit the students' ability and understanding of inquiry. The teacher collected the students' worksheets at the end of one lesson, and chaired a whole-class discussion to provide feedback in the next lesson. The teacher used rubrics to evaluate students' worksheets and identify performance levels, and formative feedback was provided to each group.

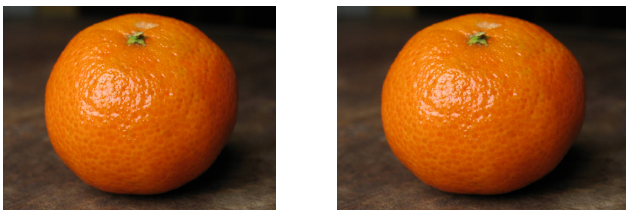
(i) How was the learning sequence adapted?

The inquiry activity was implemented according to the **Oranges** SAILS inquiry and assessment unit description in three 45-minute lessons, but the instructions of the student worksheet were slightly modified (Figure 1). To fit the measuring jugs, the oranges were replaced by tangerines. The student worksheet suggested in the unit was reworded to suit the group of students, instructing them to record their experiences.

Floating Tangerine

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.

Look at and feel the TWO tangerines. How are they different? If you placed them in water, might they float differently?



1. Talk with the others in your group and decide on a question you might ask about the tangerines.
2. Write down some possible answers to the question.
3. Test some of the ideas using the equipment provided.
4. Record the steps of the test.
5. Try and give reasons for any ideas and results that seem to answer your question.

Figure 1: Student worksheet for CS3 Hungary

To begin the lesson, the teacher wrote two questions on the board: "What happens to the tangerines in the water? What determines whether the tangerine will float or sink in the water?" Oral instructions also noted the equipment available for the experiments and that equipment could

be requested. The students were also told that they could do anything they thought was necessary with the tangerines.

The teacher had taught this class in two periods a week for only two months and therefore knew little about the students. The teacher's observations of their activities and motivations suggested that the original design should be modified. The original plan was to have the students first answer the question of what happens to the tangerine individually and then in groups, and then they would think of research questions to investigate. After talking to the groups, however, the teacher had the impression that they did not understand what questions they were supposed to ask and focused on the empirical investigation instead. After 15 minutes of group discussion, the students began their experiments with the tangerines and recorded their experiences on mobile phones and on paper (Figure 2). The teacher collected the completed worksheets and read them and at the beginning of the next class period wrote the students' questions on the board (Figure 3). Following a brief analysis, the students worked on the questions in their groups once again.

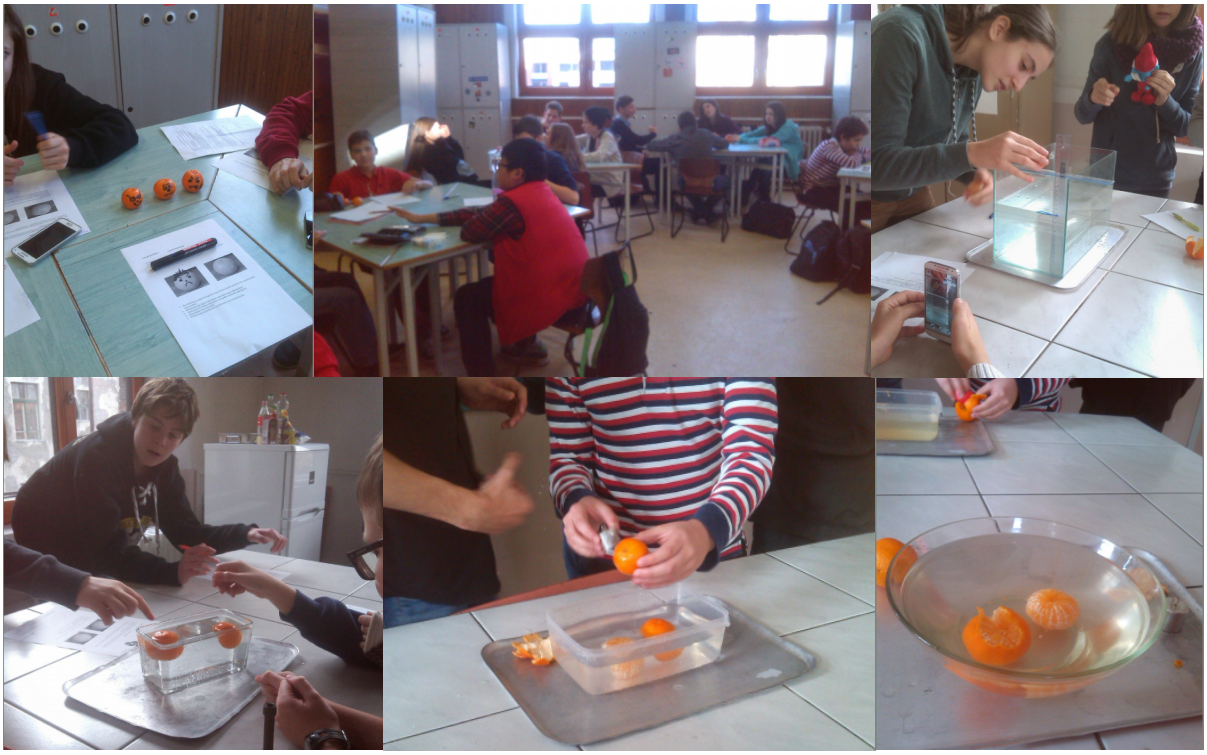
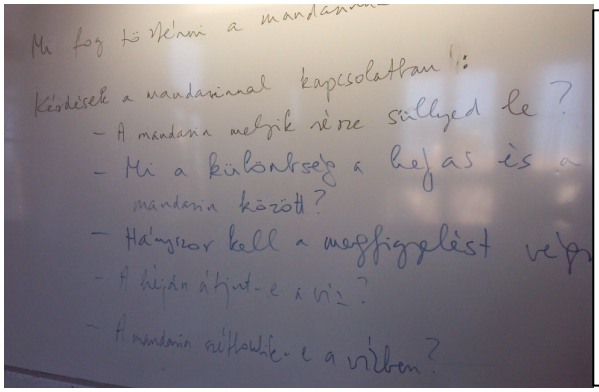


Figure 2: Student groups working on the activity.

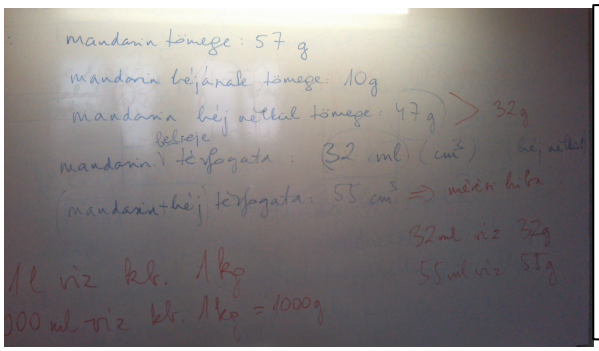


What will happen with a tangerine?

Student's questions:
- Which part of tangerine will sink?
- What is the difference between the tangerine with peel and without peel?
- How many times must we watch the effect?
- What will happen with water inside the peel?

Figure 3: Examples of students' questions.

The students referred to the results of their initial experiments when working on these questions. In the first round, practically every group did something to the peel. Every group peeled the tangerine and one group even separated the segments of the peeled tangerine. They tested the behaviour of the individual segments. Two groups tried to make holes in the peel and watch what happened.



the mass of tangerine: 57 g
the mass of peel: 10 g
the mass of tangerine without peel: 47 g > 32 g
the volume of peel inside: 32 ml (cm^3)
tangerine+peel volume: 55 cm^3 – it would be a failure
1 liter water is approximately 1 kilogram
32 ml water is 32 g
55 ml water is 55 g

Figure 4: Example of measurements.

The teacher chaired a whole-class discussion to look at the questions that could be tested by taking measurements. In the second half of the class period the students carried out measurements related to the mass and volume of the tangerines. During the first period, the teacher had the impression that the students had an entirely different idea of the task than intended. The realisation that they could not formulate open questions prompted the teacher to find out what they were thinking before carrying on with the inquiry activity. At the beginning of the second period, the teacher found out that the students had plenty of experience and knowledge, but did not know how to make measurements. They had no idea what they should measure, how and why. As it seemed clear to the teacher that the students were happy to work on the tangerine problem, she changed plans again and got the students to take all measurements that they might need. These included volume and density, which had to be introduced at the students' level of knowledge and experience. The teacher extended the originally planned implementation (two 45-minute lessons) by a third class period, when a classroom discussion was used to describe the conditions for floating (without using the concept of density). Extending the activity, the class calculated the density of the tangerine with and without its peel during the period. The teacher believes that this unstructured inquiry activity suits this age group perfectly and provides great opportunities to clarify concepts and to practice inquiry skills.

(ii) Which skills were to be assessed?

The teacher planned to assess *developing hypotheses* (hypothesis formation and asking research questions). The worksheets handed in by the students, teacher observation and classroom dialogue were used for assessment of students' performance.

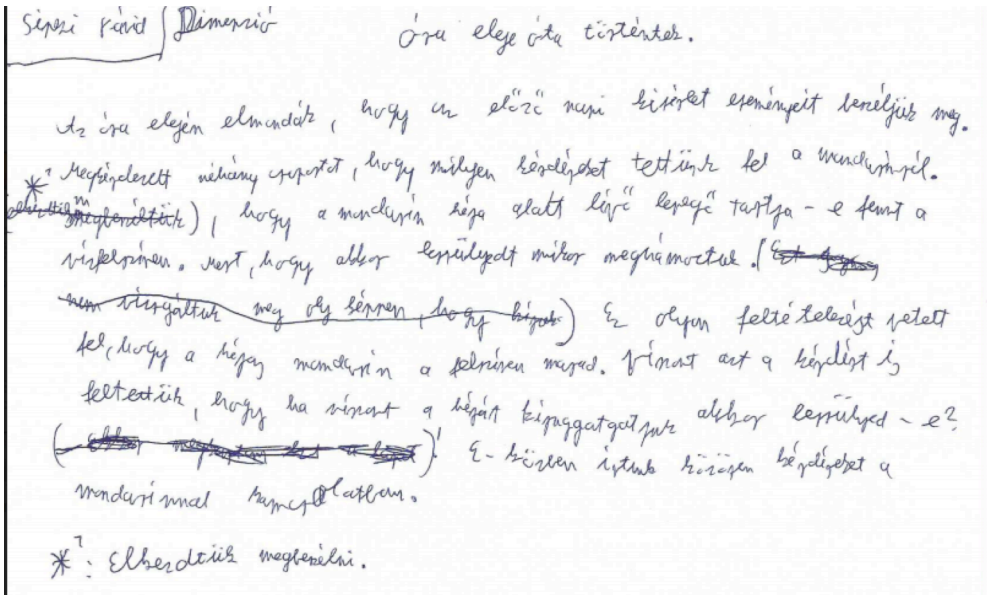
The students' work was evaluated on the basis of the scoring rubric given in the original rubric. The teacher kept to this plan and evaluated the groups based on the worksheets but reflected regularly during the activity on what the groups were doing and why. This question helped the teacher to guide the students towards the solution at their own pace and on their own level and find out together why the tangerines float or sink in water. During the lesson the teacher found that she was very busy and could not pay enough attention to the students and could not make notes.

(iii) Criteria for judging assessment data

Performance was satisfactory if the students were able to formulate a question in order to reach a goal and to recognise the physical concept behind "density." The students should recognise the importance of scientific observation and measurement. The teacher expected the students to record

their observations, share their experiences both with the teacher and with the class and be interested in the activity.

The assessment was formative; every group was given feedback according to the scoring rubric from the original unit and the teacher discussed with them what that meant for future work. The most active students and groups were also given summative evaluation but only a positive one. Students who planned the investigation testing the formed hypothesis, took notes and presented their plans to the class were given excellent marks.



What has happened since the beginning of the lesson?
We discussed what had happened with tangerine yesterday. Some groups told us which question had been examined. Most of us were interested in the air in the peel of the tangerine.

Figure 5: Example of student's work.

(iv) Evidence collected

Teacher's opinion

The students received the activity well, although at first they did not interpret the instructions of the student worksheet as I had expected. The misunderstanding was then clarified after some discussion and from then on the students worked very creatively and nicely; there were no problems with their behaviour.

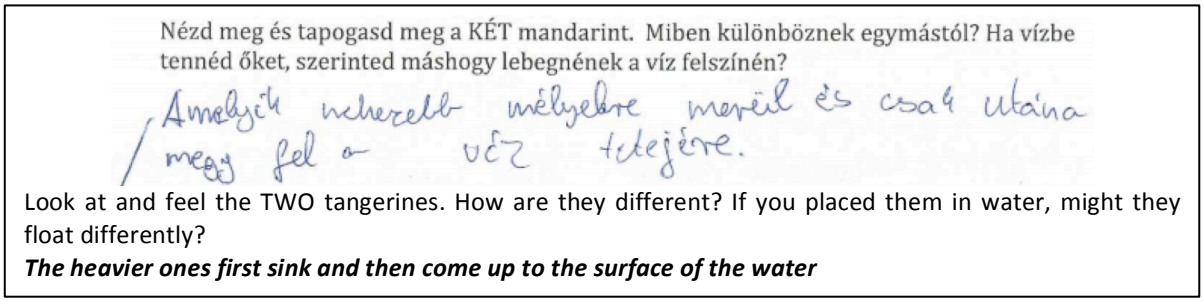
At the beginning, when the task was to make plans and formulate questions in groups, some students did not do as they were asked because they were keen to do the experiments rather than write things. After they had had the opportunity to make observations in the laboratory, they were much more successful in their work. It was a good decision to give four tangerines to each group because they could do more experiments this way. Most students did not have any difficulty taking the tangerines apart and they were very confident in their claim that the peel was the reason why the tangerines floated. During the first class period, four of the six groups showed developing level of performance in planning and implementing the experiment and the remaining two groups were at emerging level. Five groups were at emerging level and one group at developing level in formulating research questions. By the end of the second period the performance of the groups advanced one level: from developing to consolidating and from emerging to developing. I believe the progress was due to our discussions and to the observation of the students with the standards of the scoring rubric kept in mind. Thanks to the continuous feedback, they succeeded in adjusting their level.

This was the first IBL lesson for this group; therefore they needed more help and scaffolding. I tried to help them with formative questions instructing them in the planning and observing. The class engaged in dialogue during the lesson. I wrote their questions and observations on the blackboard, which I evaluated with the notes written by the groups. I used three types of rubrics, in which I adjusted the emerging and developing groups to reflect the skill levels of the class. I tried to develop the skill of two groups from the crafting to the extending level. It was very difficult to me to define the students' levels, I tried to used my experiences from both during and after the lesson when assigning performance levels.

The scoring rubric from the original unit proved to be useful because the students progressed during the three class periods and their motivation did not decline. This unit seems right as it is, since teachers can easily adjust the facilitation and adapt the method of formulating the questions to suit their classes. My class did not know how to measure, because the students did not have any experience with measurement and had no idea what density was. Only one or two students were at consolidating level and not even they could explain the results of the experiments. I shall plan the next inquiry activity taking the students' level into account.

Sample student artefacts

When looking though the student worksheets I noticed that the hypothesis formulated by one of the groups related to the tangerine immersing and surfacing (Figure 6). This group took the movement of the tangerine over time as a phenomenon to investigate. They recorded their idea on the worksheet (Figure 7). The group could not go beyond the recognition of the movement because they misinterpreted the task and did not pay attention to the guiding questions.

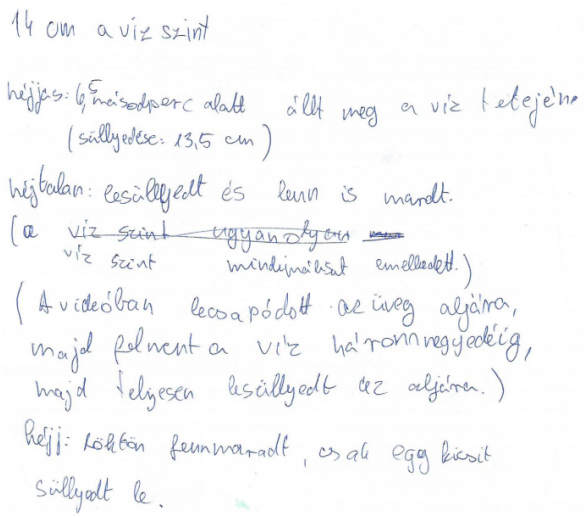

Nézd meg és tapogasd meg a KÉT mandarint. Miben különböznek egymástól? Ha vízbe tennéd őket, szerinted máshogy lebegnének a víz felszínén?

Amelyik nehezebb mélyebbre merül és csak utána megy fel a víz tetejére.

Look at and feel the TWO tangerines. How are they different? If you placed them in water, might they float differently?

The heavier ones first sink and then come up to the surface of the water

Figure 6: Examples of students' hypothesis.


14 cm a víz szint

héjjas: 6,5 másodperc alatt állt meg a víz tetején (süllyedése: 13,5 cm)

héjtalan: leesüllyedt és lenn is maradt. (a víz szint ~~ugyanolyan~~ víz szint mindig kicsit emelkedett.)

(A videóban leesa pódott az üveg aljára, majd felment a víz háromnegyedéig, majd teljesen leesüllyedt az aljáran.)

Héjj: Lökött fennmaradt, csak egy kicsit süllyedt le.

the water level 14 cm

the tangerine with peel: 6.5 sec stopped on the top of water. (sinking: 13.5 cm)

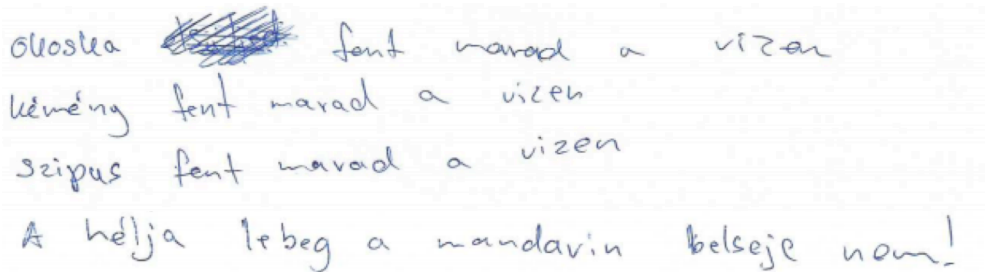
without peel: it sank to the bottom and stayed (the water level was slightly increased)

(condensation in the video at the bottom of the glass, then went up three-quarters of the water and than it sank to the bottom)

peelings: it was immediately awash.

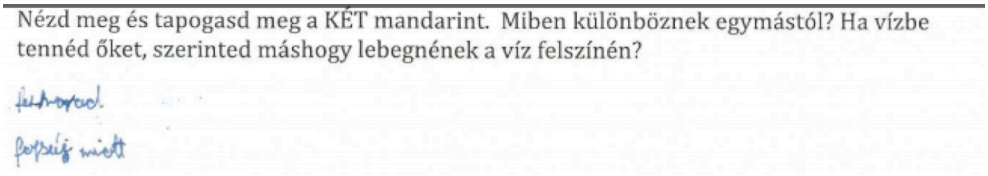
Figure 7: Results of measurement

The hypothesis was formulated by every group by answering the question “Does the tangerine float or sink in the water with or without its peel?” The students quickly found the answer to this question and only three groups were ready to move beyond (Figure 8 and Figure 9).

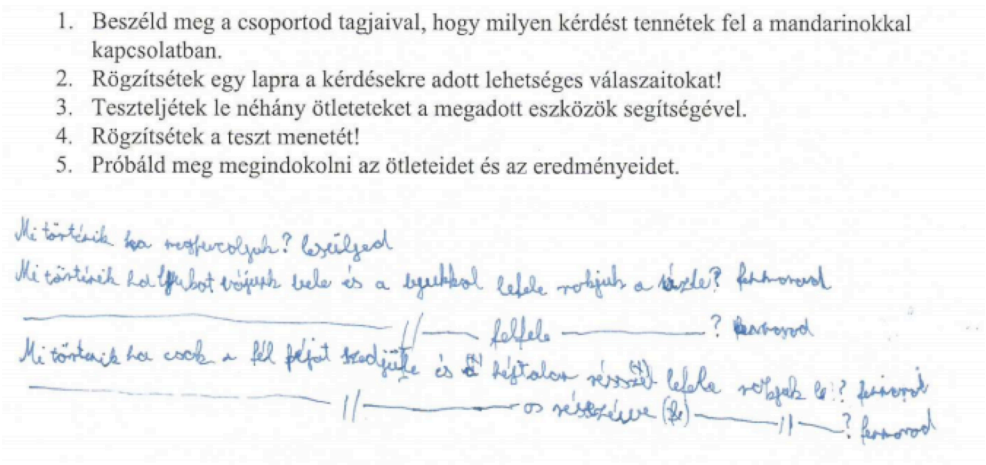


The peel floats but the inside of the tangerine doesn’t.

Figure 8: Example of students’ hypothesis.



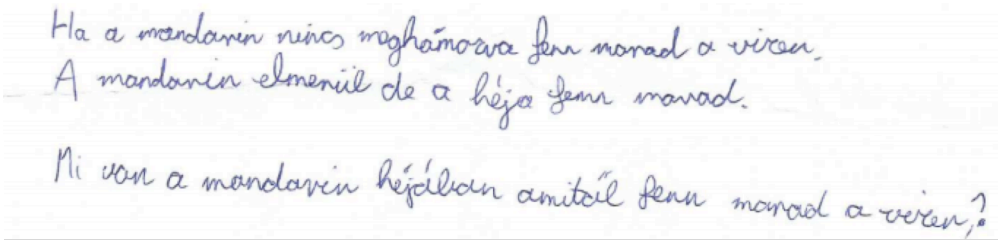
It will be floating
it is depending on the weight



What happens if peel them? They sink.
What happens if a hole is cut and turned down to the water? It is floating.
What happens if we peel it only half? It is floating.

Figure 9: Examples of hypotheses.

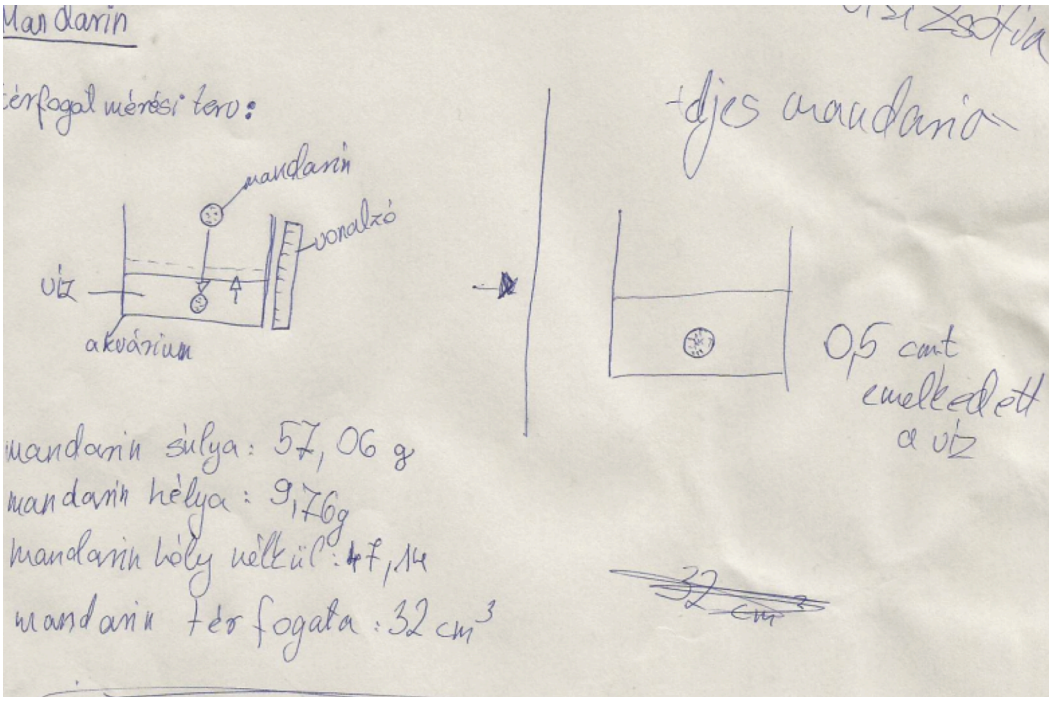
The most promising hypothesis and question were given by the group that used some sort of scientific knowledge to formulate a hypothesis. One of the groups recorded their observations and then asked a question to test (Figure 10).



Observation: ***The tangerine sinks but its peel floats.***
Question: ***What's in the tangerine's peel that makes it float?***

Figure 10: Example of forming research questions.

Recording the results of the volume and mass measurements was much more successful (Figure 11).



Tangerine:
The plan of volume measuring:

tangerine:
0.5 cm increasing water level

the weight of tangerine: 57.06 g
peelings of tangerine: 9.76 g
tangerine without peelings: 47.14
the volume of tangerine: 32 cm^3

Figure 11: Measuring volume and mass of tangerines.

(v) Use of assessment data

I gave two types of feedback to the students at the beginning and end of each class period: at the end of class I evaluated their work, attitudes and motivation; at the beginning of class I gave them feedback about their inquiry skills as demonstrated by their worksheets from the previous class.

For each class period, the pace of work was dependent on the experiences of the previous class but the main question discussed during the first class period did not change.

(vi) Advice for teachers implementing this unit

My advice to a teacher conducting an inquiry activity for the first time would be to focus on the process rather than on his or her expectations. The teacher should let the students explore their ideas and should pay close attention to the process. This activity can be implemented in several different ways and is well suited to fostering students' hypothesis development and experimental design skills, both of which are very important for unstructured inquiry tasks. I find this activity to be a very good inquiry task.