4.1 Case study 1 (CS1 Turkey)

Concept focus	Proportional reasoning Vitamin C content in everyday foods
Activities implemented	Activity A: Packed lunches Activity D: Testing for vitamin C
Inquiry skills assessed	Developing hypotheses Working collaboratively
Scientific reasoning and literacy	Scientific reasoning (proportional reasoning, drawing conclusions)
Assessment methods	Classroom dialogue Teacher observation Worksheets
Student group	**Grade:** 1st year, lower second level **Age:** 11-12 years **Group composition:** mixed ability and gender; 35 students **Prior experience with inquiry:** Some prior experience with inquiry, but only structured inquiry.

Two activities from the **Food and food labels** SAILS inquiry and assessment unit were chosen for implementation, seeking to develop students' skills in *scientific reasoning*, *developing hypotheses* and *working collaboratively*. Students were guided using a worksheet, which included a chart for recording results. The teacher tried to assess the research process, through observation of the class as they worked, and provided formative feedback. Evaluation of student worksheets allowed for further assessment of skills.

(i) How was the learning sequence adapted?

The **Food and food labels** SAILS unit was implemented in as suggested in the original unit, with some modifications. The activity was applied in lower second level, which features a module considering foods and digestion of foods in science education curriculum. Therefore this activity was conducted after the unit of curriculum. The teacher explains how he adapted learning sequences in his lesson below.

> ***I had prepared students worksheet before the lesson because I wanted to use the lesson time effectively. The worksheet included three different parts: warm-up questions, space for observer notes and a chart for saving their results. By checking on the internet, I realised that I could use lemon for ascorbic acid in the inquiry. In the beginning of the lesson my pedagogic aim was to recall students' preliminary knowledge. So I asked some questions about food ingredients which they had learned before. After this stage, I explained about the Vitamin C test and some foods that included Vitamin C. Before the investigation process, I asked student to formulate a hypothesis about which foods had a source of vitamin C.***

This activity was conducted in six teacher-allocated groups of mixed gender and mixed ability (5-6 students per group). However some groups had more than one high level student and some groups consisted of mainly low-level students.

(ii) Which skills were to be assessed?

The skills assessed in this case study were *scientific reasoning* (proportional reasoning, drawing conclusions), *developing hypotheses* and *working collaboratively*.

The teacher tried to help the students during their discussion and planning and sought to give formative feedback while observing their participation. The teacher used questions to aid the students and utilised the rubric given in the SAILS unit. Moreover, he focused on their interaction with each other and team working skills. For instance, how they managed working as a group and whether they investigated a common decision or if some groups members insisted on their own ideas. The teacher tried to observe low-level students so that if they had problems, he would guide the students to overcome them. At the end of the inquiry, the teacher looked at students' artefacts to decide which groups conducted their process in terms of their proposed hypothesis. The teacher did not contribute during the decision-making processes, and was present simply as an observer at this time. This gave students a chance to explain their results and present their research approach as a whole.

(iii) Criteria for judging assessment data

The teacher tried to assess the research process, rather than rely only on the final output. This includes how the group developed their hypothesis, how they participated in the group, their use of scientific terminology and if they reached a proper conclusion. The criteria identified by the teacher were understanding of proportional reasoning processes and applying new knowledge. However, the teacher did not identify any success criteria or performance levels for assessment of proportional reasoning. The teacher considered whether or not the groups of the students answered questions correctly.

(iv) Evidence collected

Teacher's opinion

The Food and food labels SAILS unit is suitable and useful content for lower secondary school pupils. Activity D: Testing for vitamin C was very exciting for younger ages (Figure 1). In this activity, students test the amounts of the vitamin C in daily drinks or foods, so they can find an answer for some questions: "Is it better to have fruit or juice, or Vitamin C tablet?" I think that this unit improves students' perception and awareness.

During the activity, I think some students who have a good academic achievement, showed success about inquiry skills and activity. High-level students organised and managed their group very well. Also they tested more than one variable (type of foods or drinks) for their research plan. On the other hand, low-level students could not plan very well so at the beginning of the activity they started with incorrect planning. For instance, one of the groups did not decide how much material they would use for each juice or fruit. I called this poor planning because they did everything randomly. I also understood that my students have a problem with variables (dependent and independent) after my observation.

While I was assessing group work, I listened to group's discussions and I tried to decide if they work in a group atmosphere or someone led the group as if a teacher. If groups didn't question each other's idea, I noted that they don't have a good group atmosphere.

Figure 1: Students carrying out Activity D: Testing for vitamin C

Observer notes

We had a chance to observe while the teacher and class were doing the inquiry activity. This activity was conducted with first year secondary school students. First of all, they do not have good maths skills to solve proportional comparisons, so some of the initial problems could not be solved very well. They did not use ratio and proportion while they were solving problem as expected.

Secondly, the teacher gave enough time to solve the problems after worksheets given by teacher. At the end of the time, students gave relevant responses. During this time, some conflicts were constructed by different responses from several groups. The teacher used these as feedback to reach the right answers for everyone.

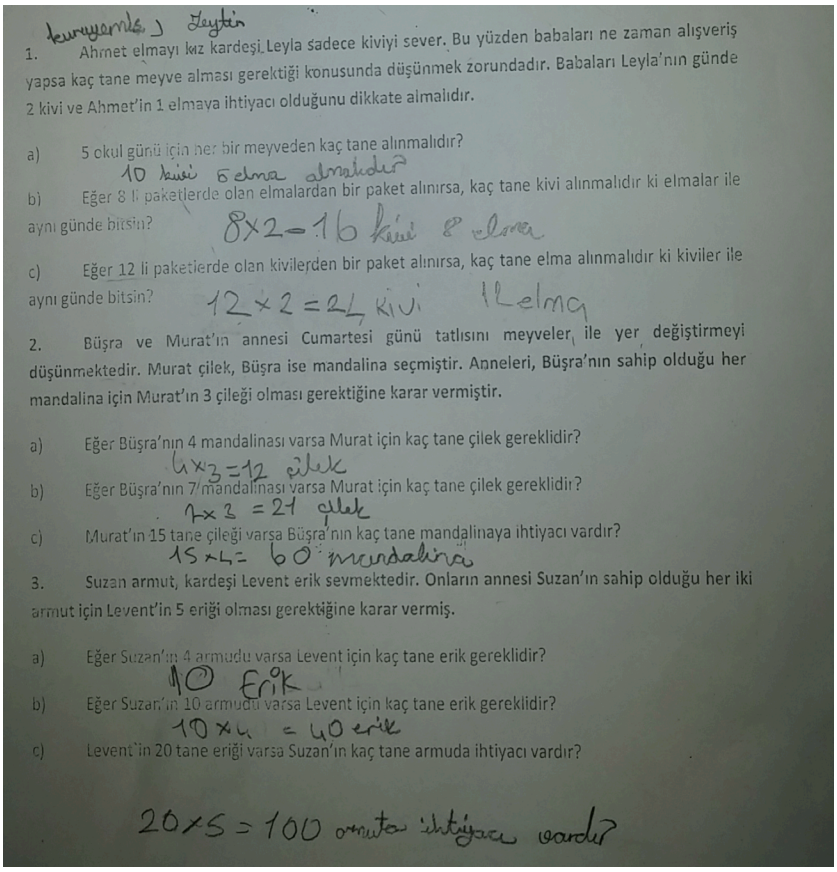
The most important point of our observation related to *developing hypotheses* and conducting an experiment based on a hypothesis. They wrote some hypothesis sentences or only one or two variables word but they did not formulate an accurate hypothesis sentences to investigate.

At the end of the unit, the teacher organised a whole-class discussion based on evidence from the investigation and every group presented their findings. After that, the teacher used the evidence to compare groups' results and he asked, "Why did we reach different results? What is the general opinion as to which foods have a good amount of Vitamin C?" The teacher and students had a good discussion and they reached a common conclusion to reach the learning goals.

Sample student artefacts

Scientific reasoning (proportional reasoning)

This artefact relates to the initial activity of the lesson, which was based on Activity A: Packed lunches. The teacher used three different questions, each with sub-questions, for development of students' skill in proportional reasoning. We can see the teacher's questions and students' answers in this example (Figure 2). However, we cannot understand how students were thinking when they solved the problem. We only see some mathematical operations. It is not a good idea to assess proportional reasoning via students' artefacts, because we can see only operations and we do not say that is an indicator of reasoning or not. Moreover, the teacher did not mention how she assessed this skill.



1. Ahmet elmayı kız kardeşi Leyla sadece kiviyi sever. Bu yüzden babaları ne zaman alışveriş yapsa kaç tane meyve alması gerektiği konusunda düşünmek zorundadır. Babaları Leyla'nın günde 2 kivi ve Ahmet'in 1 elmaya ihtiyacı olduğunu dikkate almalıdır.

a) 5 okul günü için her bir meyveden kaç tane alınmalıdır?
10 kivi 5 elma almalıdır

b) Eğer 8 li paketlerde olan elmalardan bir paket alınırsa, kaç tane kivi alınmalıdır ki elmalar ile aynı günde bitsin? 8x2=16 kivi 8 elma

c) Eğer 12 li paketlerde olan kivilerden bir paket alınırsa, kaç tane elma alınmalıdır ki kiviler ile aynı günde bitsin? 12x2=24 kivi 12 elma

2. Büşra ve Murat'ın annesi Cumartesi günü tatlısını meyveler ile yer değiştirmeyi düşünmektedir. Murat çilek, Büşra ise mandalina seçmiştir. Anneleri, Büşra'nın sahip olduğu her mandalina için Murat'ın 3 çileği olması gerektiğine karar vermiştir.

a) Eğer Büşra'nın 4 mandalinası varsa Murat için kaç tane çilek gereklidir?
4x3=12 çilek

b) Eğer Büşra'nın 7 mandalinası varsa Murat için kaç tane çilek gereklidir?
7x3=21 çilek

c) Murat'ın 15 tane çileği varsa Büşra'nın kaç tane mandalinaya ihtiyacı vardır?
15x4=60 mandalina

3. Suzan armut, kardeşi Levent erik sevmektedir. Onların annesi Suzan'ın sahip olduğu her iki armut için Levent'in 5 eriği olması gerektiğine karar vermiş.

a) Eğer Suzan'ın 4 armudu varsa Levent için kaç tane erik gereklidir?
10 Erik

b) Eğer Suzan'ın 10 armudu varsa Levent için kaç tane erik gereklidir?
10x4 = 40 erik

c) Levent'in 20 tane eriği varsa Suzan'ın kaç tane armuda ihtiyacı vardır?
20x5=100 armuta ihtiyacı vardır

1. Ahmet likes apples but his sister, Leyla, only likes kiwi fruit. So when their dad does the shopping he has to work out how many to buy. He reckons that Leyla would need 2 kiwi fruits and Ahmet would need 1 apple each day.
a) So how many of each fruit would he need to buy for 5 days in school? ***10 kiwi fruit, 5 apples are bought***
b) If he buys a saver bag of 8 apples, then how many kiwi fruits does he need to provide for the same number of days? ***8x2=16 kiwi fruit, 8 apples***
c) If he buys a saver bag of 12 kiwi fruits, then how many apples will he need to buy for Ahmet for the same number of days? ***12x2=24 kiwi fruit, 12 apples***

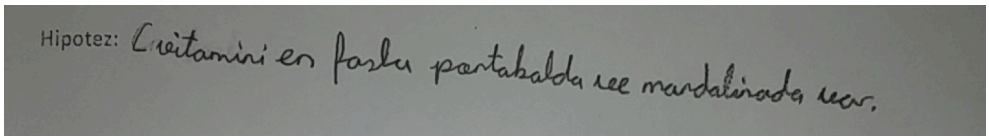
2. Murat and Büşra's mum decided to replace their Saturday sweet treat with fruit. Murat chose strawberries and Büşra chose satsumas. Mum decided that for every satsuma that Büşra had, Murat could have 3 strawberries.
a) How many strawberries does Murat get if Büşra has 4 satsumas? ***4x3=12 strawberries***
b) How many strawberries does Murat get if Büşra has 7 satsumas? ***7x3=21 strawberries***
c) How many satsumas does Büşra get if Murat has 15 strawberries? ***15x4=60 satsumas***

3. Suzan likes pears and her brother Levent likes plums. Their mum decided that for every 2 pears that Suzan had Levent could have 5 plums.
a) How many plums does Levent get if Suzan has 4 pears? ***10 plums***
b) How many plums does Levent get if Suzan has 10 pears? ***10x4=40 plums***
c) How many pears does Suzan get if Levant has 20 plums? ***20x5=100 pears, Suzan needs 100 pears***

Figure 2: Example of student worksheet

Developing hypotheses

This sample shows us a hypothesis formulated by students, who state "Vitamin C is found in orange and satsuma." It is a good example from students, because the hypothesis is appropriate in terms of lower secondary students. However, only two of the six groups produced "good" hypotheses, others did not form a proper hypothesis.



Hypothesis: ***Vitamin C is found in orange and satsuma mostly***

Figure 3: Example of developing hypotheses.

Data recording tables

These artefacts are samples of the data tables completed by group members during Activity D: Testing for vitamin C (Figure 4). The teacher prepared the blank table template before the lesson and included it with the student worksheet. Some groups of students used different amounts of drops of DCPIP for every test tube (Figure 4a), while others used a different methodology where they used the same amount of DCPIP for every test tube (Figure 4b).

(a)

Madde	Damla Sayısı
Portakal	15
Mandalina	30
Kivi	17
Greyfurt	11
Gold	40
Cappy	13

(b)

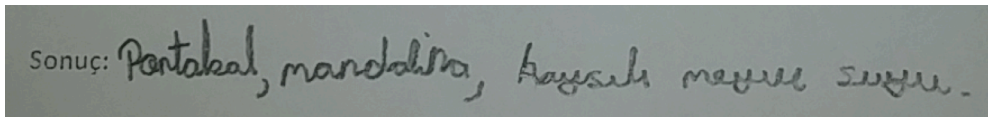
Madde	Damla Sayısı
Portakal	12
Mandalina	12
Greyfurt	12
Meyve Suyu	12
Kivi	12

Figure 4: Examples of data collection tables. Portakal = orange, mandalina = mandarin, kivi = kiwi, greyfurt = grapefruit, gold = brand of fruit juice or fruit soft drinks, cappy = brand of fruit juice or fruit soft drinks, meyve suyu = fruit juice

Scientific reasoning (drawing conclusions)

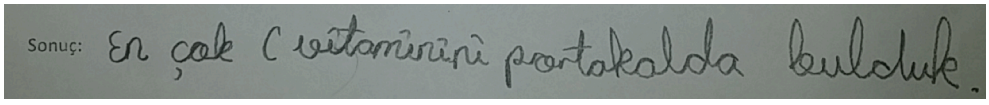
The students' skill in drawing conclusions has not been well developed. Investigation results were too short, consisting of only some words (Figure 5a) and explanation of experiment findings (Figure 5b) and as a hypothesis sentences (Figure 5c).

(a)



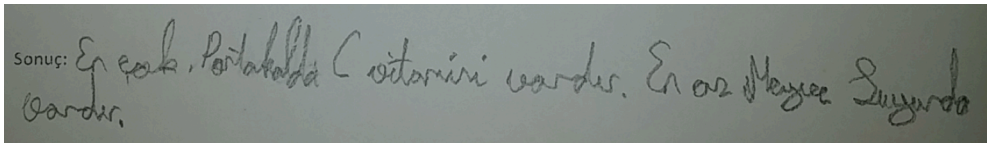
Result: ***Orange, mandarin and mixed fruit juice***

(b)



Result: ***We found that orange has most Vitamin C***

(c)



Result: ***Orange includes most amount of Vitamin C and least amount of Vitamin C is in mixed fruit juice***

Figure 5: Examples of drawing conclusions.

(v) Use of assessment data

The teacher used the assessment rubric and observation data to assess students' skills. According to the teacher, the main problems were experienced in *developing hypotheses* and *planning*

investigations. The teacher provided a short explanation using a worksheet because students have not conducted guided inquiry activities previously. The worksheet included a short plan (not detailed) and data charts. Some students who have low academic levels did not develop hypotheses at all. They used only words to compare ("Satsuma? or orange?") and they did not implement their plan carefully. Therefore, the teacher focused mainly on these students, because he needed to give feedback to support their inquiry. The two groups with mostly high academic performance students worked independently and their plans were conducted without teacher guidance.

After the food label unit, the teacher wants to apply some other activities that focus on *developing hypotheses* and *planning investigations*. The students appeared to enjoy these activities because content comes from a daily context and also they activities with some experimental inquiry.

(vi) Advice for teachers implementing the unit

Teachers should focus on the assessment of students' skill in proportional reasoning, as this is a difficult skill to assess. You could prepare a rubric with some detail of expectations, which might be easier than observation alone.