4.2 Case study 2 (CS2 Hungary)

Concept focus	Composition and nutritional values of foods Designing a healthy meal
Activities implemented	Activity A: Packed lunches Activity B: Food cards Activity C: The washing line Activity D: Testing for vitamin C
Inquiry skills	Developing hypotheses Planning investigations Forming coherent arguments Working collaboratively
Scientific reasoning and literacy	Scientific reasoning (proportional reasoning, collecting data) Scientific literacy (analysis and interpretation of data)
Assessment methods	Classroom dialogue Worksheets Student devised materials
Student group	**Grade:** 8th grade, lower second level **Age:** 14 years **Group composition:** mixed ability and gender; 31 students **Prior experience with inquiry:** No prior experience with inquiry in the classroom. The students had been given similar tasks before but those activities had been completed individually or in pairs outside regular school classes. This was the first time both for the teacher and for the students to use this method as a classroom activity.

This case study describes full implementation of the **Food labels** inquiry and assessment unit, with modifications to fit with the level of the students and availability of materials. The skills assessed were *scientific reasoning*, *planning investigations, forming coherent arguments* and *working collaboratively*. The teacher prepared four-level rubrics for assessment of these skills, observed students during the activities and gave feedback on-the-fly.

(i) How was the learning sequence adapted?

The activities of the **Food and food labels** SAILS unit are well matched to the content and goals of the Hungarian curriculum in the area of nutrition. The students learnt the necessary theoretical background during their classes on food, nutrients and healthy eating. They looked at the composition and nutritional values of foods and learnt to appreciate the usefulness of the information on food labels when doing their shopping. The teacher slightly modified the unit to suit the knowledge and interests of the students and the available equipment, materials and time. The unit was implemented in full, with three distinct activities identified:

- Exercises on proportional reasoning (Activity A: Packed lunches)
- Measurement of vitamin C content (Activity D: Testing for vitamin C)
- Analysis of the nutritional value and energy content of school lunches and planning a daily menu with nutritional values and calories (Activity B: Food cards and Activity C: The washing line)

Lesson sequence

1. Proportional reasoning

The students worked individually in class and took about 15 minutes to complete the exercises on their worksheets (Figure 1). At first they treated the task as a mathematical problem. To make sure

that their solutions would reflect their real competencies, I motivated them by saying, "You're participating in an international research project. Please make me proud."

Exercise 1.
John likes apples but his sister, Ruby, only likes kiwi fruit. So when their dad does the shopping he has to work out how many to buy. He reckons that Ruby would need 2 kiwi fruits and John would need 1 apple each day.

a) How many of each fruit would he need to buy for 5 days in school?
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?
c) If he buys a saver bag of 12 kiwi fruits, then how many apples will he need to buy for John for the same number of days?

Exercise 2.
Jack and Amy's mum decided to replace their Saturday sweet treat with fruit. Jack chose strawberries and Amy chose satsumas. Mum decided that for every satsuma that Amy had, Jack could have 3 strawberries.

a) How many strawberries does Jack get if Amy has 4 satsumas?
b) How many strawberries does Jack get if Amy has 7 satsumas?
c) How many satsumas does Amy get if Jack has 15 strawberries?

Exercise 3.
Susan likes pears and her brother Lee likes plums. Their mum decided that for every 2 pears that Susan had Lee could have 5 plums.

a) How many plums does Lee get if Amy has 4 pears?
b) How many plums does Lee get if Amy has 10 pears?
c) How many pears does Amy get if Lee has 20 plums?

Exercise 4.
A lunchbox has a packet of crisps that weighs 25 g and contains 8 g of fat per 100 g of crisps. How much fat is there in 1 bag of the crisps?

a) 2 g b) 8 g c) 25 g d) 32 g e) 100 g

Exercise 5.
Wheetos crisps are sold in 30 g bags and contain 6 g of fat per 100 g of crisp. Quipo crisps are sold in 20 g bags and contain 7.5 g of fat per 100 g. Which bag of crisp contains the most fat?

Exercise 6.
Most crisps contain about 80 g of carbohydrate per 100 g of crisp. Bread has about 40 g of carbohydrate in every 100 g. A slice of bread weighs about 50 g, so what amount of crisps contains the same amount of carbohydrate?

a) 8 g b) 20 g c) 25 g d) 40 g e) 100 g

Exercise 7.
A 125 g pot of fruit yoghurt had the following food label:

Energy	500 kJ
Protein	5 g
Carbohydrate	25 g
Fat	1 g
Vitamin C	1.25 mg
Calcium	200 mg

a) How much of each food type would there be in a 250g pot?
b) How much of each food type would there be in a 100g pot?

Figure 1: Student worksheet for assessment of proportional reasoning capabilities

How much vitamin C in...

Materials: 60 mg vitamin C (ascorbic acid), oranges (25 cm^3 orange juice), starch solution, potassium iodide solution (KI solution), distilled water, lemons, tomatoes, pure fruit juice (25 cm^3)

Equipment: 50 cm^3 beakers, glass rod, droppers, test tubes and rack, 25 cm^3 measuring cylinder, citrus squeezer

Experiment 1

Pour starch solution into the test tube to the height of about 2 cm. Add a few drops of KI solution.
Observations: When we added the drops, the solution turned _____ in colour.
Explanation: Starch mixed with iodine gives this characteristic colour.

Experiment 2

Dissolve a 60 mg vitamin C tablet (this is the minimum vitamin C requirement of a person) in distilled water (about 50 cm^3) in a beaker. Add about 1 cm^3 starch solution to the beaker. Now keep stirring the mixture with the glass rod and at the same time add KI solution one drop at a time until the change in colour is complete.

Observation:

Explanation: Vitamin C reacts with iodine. *Vitamin C reduces iodine to iodide ions and the colouring caused by the iodine and starch combination disappears.*

Why does this colour remain later?

Experiment 3

Using the materials and equipment on the tray, how could we determine the amount of vitamin C in 25 cm3 of orange juice?

Plan the experiment:

Observations:

Explanation:

4 What further questions can you ask based on the results of the experiments?

5 Choose one of the questions listed above and find an answer to it using the materials, equipment and information at your disposal.

6 What would you recommend based on your experiments? Should people satisfy their vitamin needs by taking vitamin tablets or by having fruits and vegetables? Explain your decision.

Figure 2: Student worksheet for testing for vitamin C

2. Measurement of vitamin C content

We could not carry out the experiment to measure Vitamin C content as described in the unit because we did not have access to dichlorophenol-indophenol. The teacher instead adapted Ildikó Hanga's "Oranges and Science" experiment to the IBSE method (available in Hungarian from http://www.chem.elte.hu/w/modszertani/letoltesek/Hanga_Ildiko_Narancs2013febr1.doc [accessed 30/03/2015]). This details a redox method for determination of vitamin C using potassium iodide and starch indicator. The students worked in groups and they followed the instructions given in their worksheet (Figure 2). This activity was used to assess students' skills in *planning investigations*, *developing hypotheses* (forming research questions) and *forming coherent arguments*.

3. Calorie and nutritional content of food

The last part of the activity departed from the original unit because the students were confident users of the tables of nutritional content and making food labels did not present a challenge to them. They used an online database instead. Wi-Fi was available in the classroom, each group had a tablet computer and the students were also allowed to use their smartphones (two-thirds of the class had one), which they had anticipated with great joy. The groups followed the instructions in their worksheets (Figure 3).

(ii) Which skills were to be assessed?

The skills assessed in this case study were *scientific reasoning* (proportional reasoning), *planning investigations, forming coherent arguments* and *working collaboratively*. The teacher prepared rubrics for assessment of these skills. The teacher observed students during the activities and gave feedback on-the-fly.

Calorie and nutritional content of food

1. Using the calorie calculator at the hyperlink, calculate the amount of energy and nutrients you need to maintain your body weight. Write down the data. What is the explanation for the differences?

http://orvosilexikon.hu/wrap.php?file=dcc.html

2. Analyse the lunch menu of the school with respect to calorie content and nutritional value. What were the most important considerations in putting this menu together?

Which day's menu (with morning snack, lunch and afternoon snack combined) has the highest and the lowest calorie, fat, protein and carbohydrate content? Provide evidence for your answers.

	Morning snack	Lunch	Afternoon
12.01 Monday	Lemon tea Sandwich spread with chives Sesame seed roll Carrots	Soup with potato dumpling Broccoli cheese bake Fruit compote Wholemeal bread	Chicken liver pate Roll with oat flakes
	Energy: 278.63kcal Protein: 5.87g Fat: 9.06g Carbohyd.: 43.09g Sugar: 10.2g Salt: 0.37g	Energy: 688.15kcal Protein: 28.06g Fat: 29.94g Carbohyd.: 72.84g Sugar: 12.21g Salt: 2.69g	Energy: 299.1kcal Protein: 11.97g Fat: 10.93g Carbohy.: 32.35g Sugar: 0.76g Salt: 1.25g
13.01 Tuesday	White coffee Break roll	Soup with noodles Turkey stir fry Boiled cabbage Spelt croissant with cheese	Yoghurt Cheese roll
	.ergy: 300.73kcal Protein: 11.5g Fat: 6.04g Carbohy.: 53.35g Sugar: 13.65g Salt: 0.54g	Energy: 730.95kcal Protein: 31.55g Fat: 33.75g Carbohyd.: 66.43g Sugar: 2.37g Salt: 4.76g	Energy: 280.79kcal Protein: 11.39g Fat: 10.77g Carbohy.: 36.65g Sugar: 0.94g Salt: 0.44g
14.01 Wed	Milk Krasno ham Whole wheat roll White radish	Spring vegetable soup Fish stew Pasta Wholemeal bread Orange	Cheese spread Corn bread Apple
	Energy: 315.06kcal Protein: 21.57g Fat: 10.45g Carbohyd.: 40g Sugar: 0.76g Salt:1.29g	Energy: 691.13kcal Protein: 35.81g Fat: 15.58g Carbohyd.: 97.81g Sugar: 1.14g Salt: 3.55g	Energy: 283.8kcal Protein: 8.2g Fat: 6.6g Carbohyd.: 46.8g Sugar: 0.88g Salt: 0.98g
15.01 Thur	Milk Butter cake	Beef stock Pork chops Mixed fruit sauce Half portion of boiled potatoes Wholemeal bread	Cheese Margarine Brown roll Cucumber
	Energy: 294.8kcal Protein: 14.7g Fat:6.2g Carbohyd.: 47.3g Sugar: 1.79g Salt: 1.76g	Energy: 617.11kcal Protein:30.15g Fat:12.15g Carbohyd.: 90.09g Sugar: 21.02g Salt: 3.51g	Energy: 299kcal Protein: 16.2g Fat: 13.19g Carbohy: 31.48g Sugar: 0.81g Salt: 1.03g
16.01 Friday	Lemon tea Cottage cheese with parsley and sour milk Seeded bread	Kidney bean soup Semolina pudding Wholemeal bread Apple	Brioche Kiwi
	Energy: 268.02kcal Protein: 12.64g Fat: 4.72g Carbohyd.: 43.26g Sugar: 9.78g Salt: 0.66g	Energy: 746.69kcal Protein: 31.59g Fat: 21.7g Carbohyd.: 105.56g Sugar: 19.48g Salt: 1.69g	Energy: 291.2kcal Protein: 7g Fat: 4.2g Carbohyd.: 55.3g Sugar: 1.75g Salt: 0.18g

3. Put together a three course dinner from the foods listed at the hyperlink below that you would be pleased to see on the school menu. Note the energy content and nutritional value of each food. Discuss whether your menu meets the considerations you determined in Question 2.

http://www.fogyas.info/tapanyag-kaloria-energiatablazat_kcal-kalkulator.php

Figure 3: Student worksheet for evaluating calorie and nutritional content of food

(iii) Criteria for judging assessment data

Scientific reasoning (proportional reasoning)

This skill was assessed by analysis of student responses to the questions on the worksheet. The solutions to exercises 5 and 7 are instructive. Two methods were used to establish the absolute fat content of packets of crisps of different masses and fat contents. Some of the students used mathematical calculations, while others made their decision using proportional reasoning.

In the last exercise, the nutritional content of the 125 g packet of yoghurt was given. The students quickly realised that the nutritional content of the 250 g packet of yoghurt should be twice that much. Their mistakes consisted in omitting or misspelling the unit of measurement. A different strategy was needed, however, to establish the nutritional content of 100 g of yoghurt. Some of the students did not have time to complete this task or gave up trying to find a solution.

Developing hypotheses

This skill was assessed during the second activity (testing for vitamin C), where in question 4 students are asked "What further questions can you ask based on the results of the experiments?" The teacher had hoped that students would think of investigating the difference between different kinds of fruit or other foods that were not already provided.

Planning investigations

Activity D: Testing for vitamin C was identified as a key opportunity to assess students' skills in *planning investigations*. The worksheet detailed three experiments (Figure 2). The first two experiments were included to gather information and find a solution to the problems given in the remaining exercises. Since the students did not have the knowledge of chemistry needed to understand the experiments, some explanation from the teacher was essential. The IBSE method was used for the rest of the activity. The students had to measure the vitamin C content of a unit of orange juice. They had to design and implement the experiments, formulate further research questions and finally make a decision in connection with satisfying the vitamin C requirements of people. To find a solution, the students had to design the experiment based on the ideas from the first two experiments. The groups varied in their performance and needed different levels of educator assistance.

The teacher identified four levels of performance for assessment of students on their skill in *planning investigations* (Table 1). The teacher also considered their ability in implementing an investigation, but found little differentiation between the student groups as they showed expertise in the use of equipment and used materials safely and as intended.

Table 1: Assessment of planning investigations

Emerging	Developing	Consolidating	Extending
Students only partially understand the task. Their ideas are incoherent and do not form a system. They work out a strategy with the teacher's help.	Students do not recognise the relationship between vitamin C content and KI drops, and thus their experimental plan is arbitrary.	Students understand the task. They recognise the connection between vitamin C content and KI drops but cannot figure out how to measure concrete quantities.	Students quickly understand the task. They work out an efficient strategy by analysing the previous experiment. They make a detailed plan, broken down into individual steps.

Forming coherent arguments

Two opportunities to evaluate this skill were identified. Evaluation of students' skill in drawing conclusions based on scientific evidence was evaluated during the second activity (testing for vitamin C). The teacher identified four performance levels for students' ability to form arguments based on scientific evidence (Table 2).

Table 2: Assessment of forming coherent arguments – drawing conclusions

Emerging	Developing	Consolidating	Extending
Students need the teacher's help to use their data as evidence and to measure quantities	The conclusions are incomplete. There is no interpretation. Students need the teacher's help to move on.	The conclusions rest on comparisons and proportions. The conclusions lack interpretation. The quantities are calculated with the teacher's help.	The conclusions are correct and are based on arguments from correctly interpreted evidence

A second opportunity to evaluate students' ability to form coherent arguments was in the final task, when students were asked to analyse school lunches. The teacher used a further four-level rubric to evaluate students' skill in making reasoned decisions (Table 3).

Table 3: Assessment of forming coherent arguments – making reasoned decisions

Emerging	Developing	Consolidating	Extending
The principles are formulated in general terms without consideration of the data.	Partial reliance on the data. Incomplete or occasionally erroneous decisions.	The decisions are correct and are based on the data but some elements are absent.	The decisions are correct and complete; they cover daily calorie intake, the general calorie content of meals and the proportions of individual nutrients.

Working collaboratively

This was assessed during the final activity. The groups were efficient and successful if they distributed tasks among the members, were good at communicating with each other, supported their opinions with arguments, paid attention to and supplemented each other's arguments and formulated a uniform stance. The teacher used a rubric with four performance levels to evaluate this skill (Table 4).

Table 4: Assessment of working collaboratively

Emerging	Developing	Consolidating	Extending
The jobs are distributed among the members. There is no appropriate communication, the completed jobs are isolated pieces of information with no connection between them.	The jobs are distributed with a goal in mind. They listen to each other's opinions but do not consistently reflect on them.	The jobs are distributed efficiently. Communication is continuous. They reflect on each other's opinions but their arguments lack confidence.	The jobs are distributed efficiently and they crosscheck results. Their arguments are based on evidence and they formulate a uniform stance endorsed by every member.

Scientific reasoning (collection of data) and scientific literacy (analysis and interpretation of scientific results)

These skills were assessed together during the final activity. The students were asked to evaluate the school menu and propose an alternative. The teacher was seeking consistency in recording of

information, and expected that students would use tables as appropriate. This was evaluated in connection with *forming coherent arguments* and an ability to make reasoned decisions.

(iv) Evidence collected

Teacher's opinion

The teacher provided some notes and suggestions for various parts of the activity.

2. Testing for vitamin C

- The first challenge the educator has to face is procuring 60 mg of vitamin C for the experiment. We used ascorbic acid for this purpose with the approximate quantity measured at a chemists.
- We should use a starch solution of low concentration for the experiment because this allows us to do the experiment with less potassium iodide and in a shorter time.
- As a teacher, I had previously preferred strictly structured activities with step-by-step exercises. These are needed to establish an experimental routine but do not leave any room for creativity or the development of individual ideas. The advantage turns into a disadvantage that constricts thinking.

3. Calorie and nutritional content of food

- The students found the task using a calorie calculator online very interesting, which gave them the motivation to do further exercises.
- The background information collected was pertinent to the activity and contained very few or no mistakes. The students used the tables of nutrients confidently.
- When evaluating the school's lunch menu, half of the groups recorded the data in a table. The problems with systematic data recording were reflected in the students' decisions as mistakes or omissions.
- Exercises involving use of the internet and/or their own phones were highly motivating for the students. They enjoyed working on these tasks. However, the work was occasionally interrupted because of an uneven internet connection and overloaded Wi-Fi network. Stable and reliable IT services are needed for efficient work.
- The school regulations specify that students' mobile phones must be switched off during classes but smartphones could be incorporated into classroom activities if their use was appropriately regulated.

Sample student artefacts

Scientific reasoning (proportional reasoning)

The teacher evaluated the student responses to each of the exercises in worksheet 1, and found that the average result was 83%. However, the actual grades ranged from 42-100%. Analysis of the results by exercise instead showed that, in general, students did not have difficulty with questions 1-4, but questions 5 and 6, and the latter parts of question 7 proved much more challenging (Figure 4).

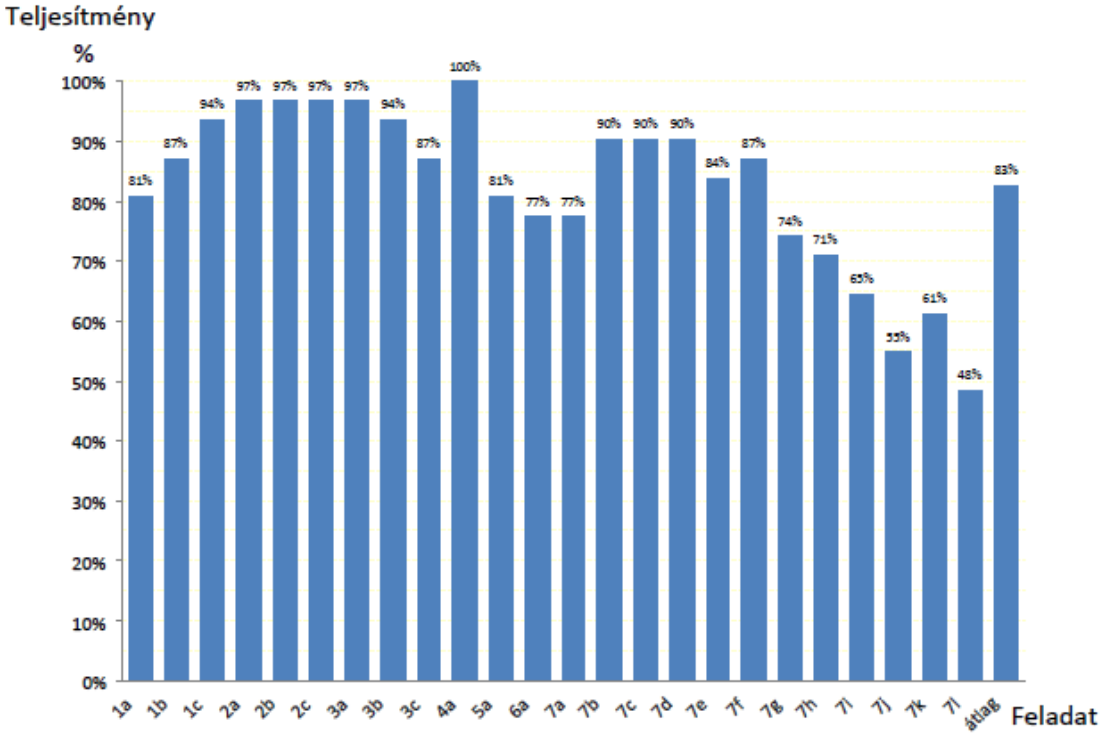


Figure 4: Analysis of student performance (y-axis) per task (x-axis) during development of proportional reasoning skills.

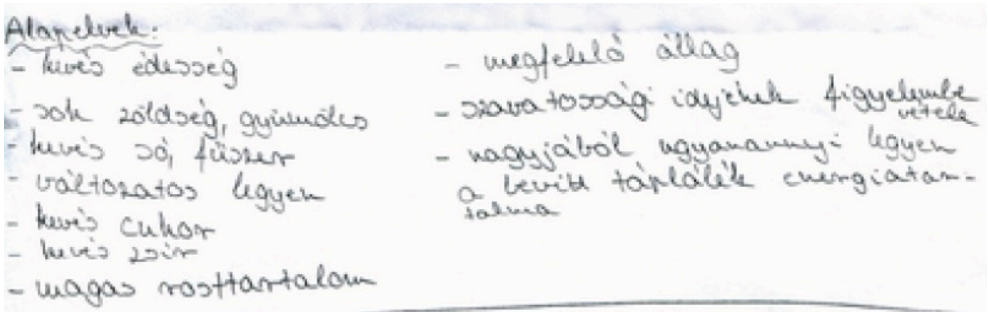
Developing hypotheses

The groups show uniform performance in this respect and fixate on a single issue. They do not think of investigating the difference between different kinds of fruit in vitamin C content and do not ask how much of each we should consume to reach sufficient vitamin C intake. They do not move beyond measuring the vitamin C content of the drinks and vegetables on the tray. They prepare appropriate experimental plans to answer the research questions and implement their plans, some of the time following an algorithm previously developed with the help of the teacher.

Forming coherent arguments

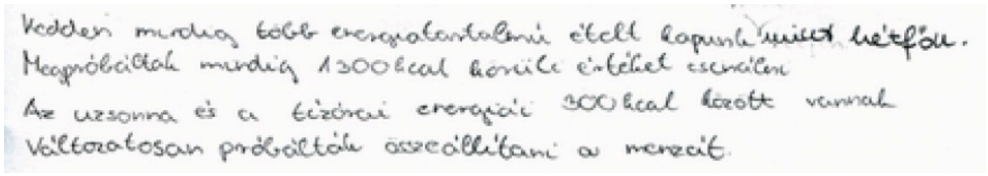
One opportunity to assess students' skill in *forming coherent arguments* was during the activity to test for vitamin C, in which students are asked, "Should people satisfy their vitamin needs by taking vitamin tablets or by having fruits and vegetables? Explain your decision." Most of the students decide on taking vitamin C tablets because they have a higher vitamin C content. Their decision is probably influenced by the media through vitamin C advertisements. Two groups recommend consuming vegetables and fruits to satisfy vitamin C needs but this recommendation was based on their previous studies rather than on the results of the experiments.

When evaluating the school's lunch menu, half of the groups recorded the data in a table. The problems with systematic data recording were reflected in the students' decisions as mistakes or omissions. Examples of student work, evaluated using a four-level rubric (Table 3) are shown in Figure 5, Figure 6, Figure 7 and Figure 8.



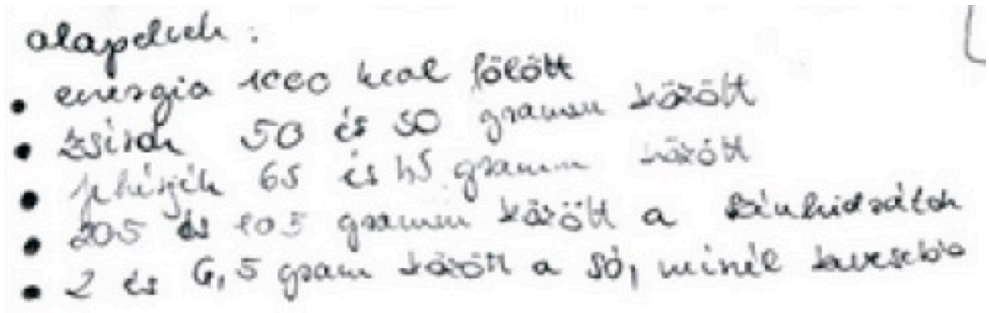
Main considerations: little dessert, a lot of fruit and vegetables, little salt and spices, it should be varied, little sugar, little fat, high fibre content, appropriate state, best-before dates should be noted, the intake of nutrients should have about the same energy content

Figure 5: Decision making at an emerging level.



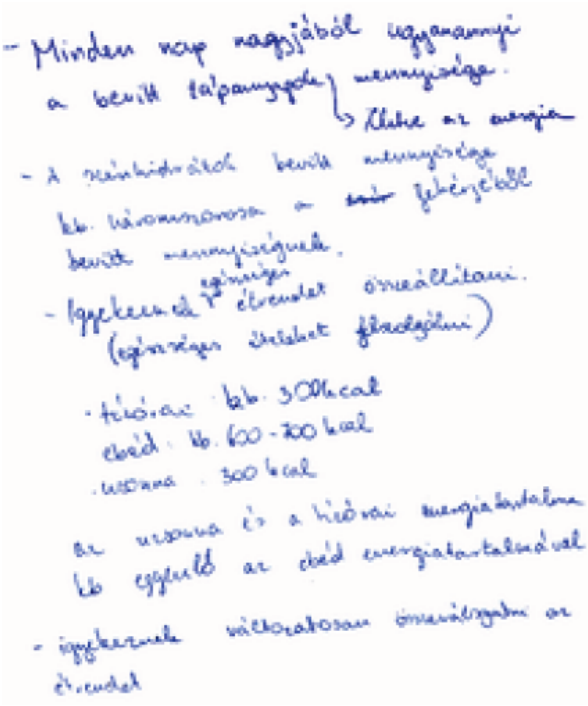
We get food with higher energy content on Tuesday than on Monday. They always try to have the energy content around 1300 kcal. The afternoon and morning snacks have about 300 kcal. They tried to put together a varied menu.

Figure 6: Decision making at a developing level.



Main considerations: energy above 1000 kcal, fat content between 50 and 30 g; protein content between 65 and 45 g; carbohydrate between 205 and 105 g; salt between 2 and 6.5 g, as little as possible.

Figure 7: Decision making at a consolidating level.



- *The nutrient intake is about the same every day (or at least the calorie intake)*
- *Carbohydrate intake is about three times as high as the protein intake*
- *They try to put together a healthy menu (to serve healthy meals)*
- *Morning snack about 300 kcal, lunch about 600-700 kcal, afternoon snack about 300 kcal. The energy content of the afternoon and the morning snacks is about the same as the energy content of lunch*
- *They try to put together a varied menu*

Figure 8: Decision making at an extending level

Scientific reasoning (collection of data) and scientific literacy (analysis and interpretation of scientific results)

School lunches satisfying the criteria of a healthy diet are an everyday topic of conversation among the students. In the final activity, I chose the weekly menu as the object of our investigations. After collecting and analysing the data, we had to specify the principles of constructing our own menu. The students then had to put a menu together based on the hyperlink given to them and to evaluate their menu with respect to the principles of constructing a menu. For example, students proposed of a school menu where lunch is cream of broccoli soup, main course consists of a kebab in pita bread with Greek salad and the pudding is custard with egg white dumplings and provided calories, protein, carbohydrate, fat and fibre content for each meal.

(v) Advice for teachers implementing the unit

Both the teacher and students enjoyed the class (Figure 9). It provides an opportunity for both to show creativity. It is a welcome change from everyday routines. An activity like that holds a mirror to the educator because the shortcomings of regular classroom practices become manifest.

Figure 9: Students carrying out the activities