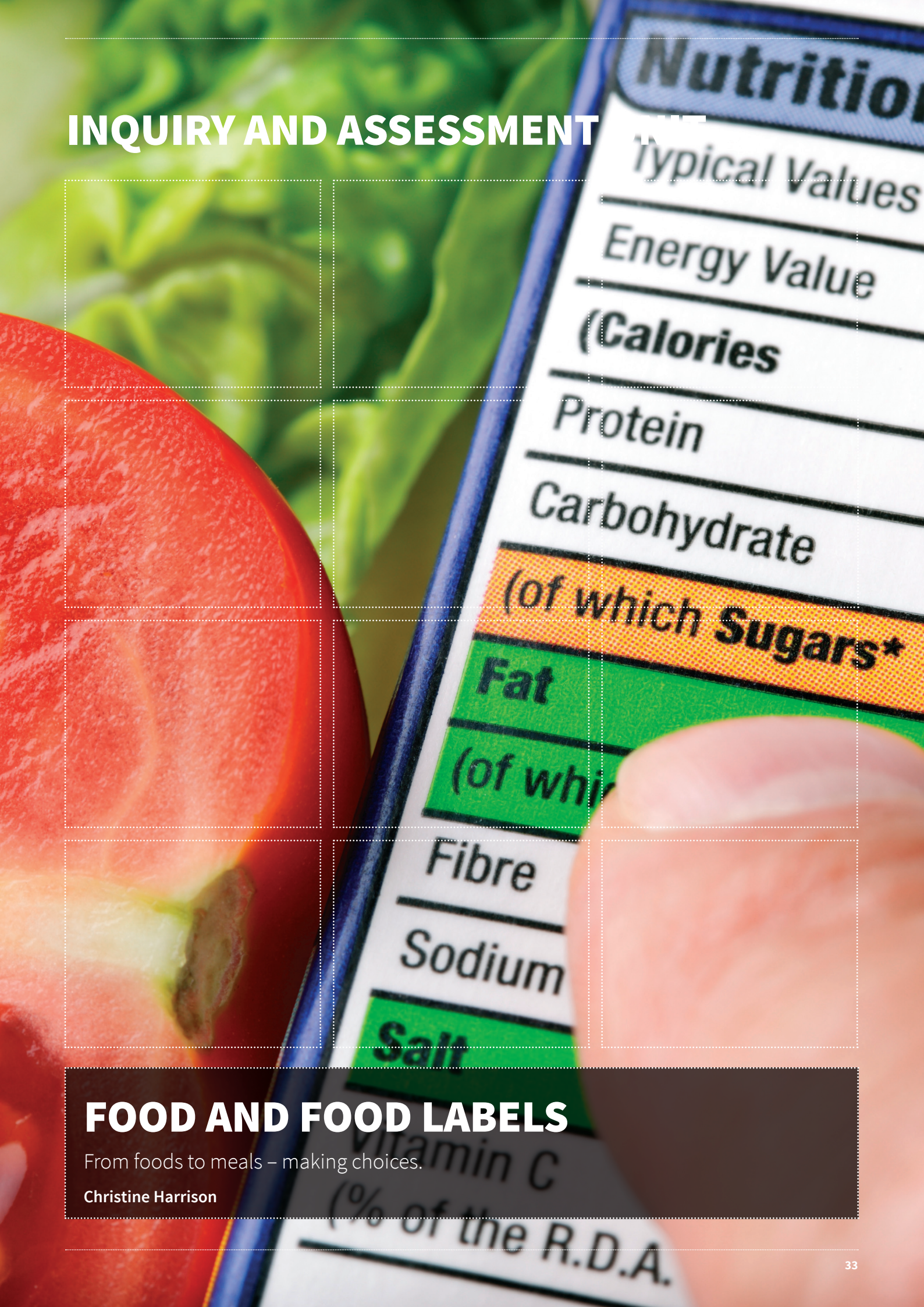

FOOD AND FOOD LABELS

From foods to meals – making choices.

Christine Harrison

FOOD AND FOOD LABELS

FROM FOODS TO MEALS – MAKING CHOICES.

Overview

KEY CONTENT/CONCEPTS

- Nutritional content of different food items
- Balanced diet
- Food groups
- Understand food label information

LEVEL

- Lower second level
- Upper second level

INQUIRY SKILLS ASSESSED

- Planning investigations
- Developing hypotheses
- Forming coherent arguments
- Working collaboratively

ASSESSMENT OF SCIENTIFIC REASONING AND SCIENTIFIC LITERACY

- Scientific reasoning (proportional reasoning; drawing conclusions; collecting scientific data; problem-solving)
- Scientific literacy (analysis and interpretation of scientific data)

ASSESSMENT METHODS

- Classroom dialogue
- Teacher observation
- Self-assessment
- Worksheets
- Student devised materials (group work placemat, reports)
- Presentations

Classroom materials for this Inquiry and Assessment Unit are available at WWW.SAILS-PROJECT.EU

1. INQUIRY AND ASSESSMENT UNIT OUTLINE – FOOD AND FOOD LABELS

The **Food and food labels** SAILS inquiry and assessment unit was designed to aid students to understand what constitutes a healthy balanced diet. Through the four outlined inquiry activities, students learn to look at the composition of foods and the amounts needed to keep someone healthy. In this way, students become equipped with sufficient knowledge and skills to make informed choices when it comes to their own diet. The unit is recommended for implementation as a *guided inquiry* with students at lower second level.

Two key skills are identified for development in this unit. *Scientific reasoning*, in particular proportional reasoning, is developed as students compare different amounts and types of food in their diet. Students' skills in *working collaboratively* are also developed, through discussion and teamwork. The assessment methods described include classroom dialogue, teacher observation and evaluation of student artefacts.

The unit was trialled by teachers in Turkey, Hungary, Ireland and Portugal – producing five case studies of implementation. Four examples at lower second level are presented (aged 11-15 years), while one of the Hungarian classes and the Portuguese study describe implementation with students at upper second level (up to 19 years). In all cases the unit was implemented as a *guided inquiry*, with some *open inquiry* opportunities. In addition to the assessment of *scientific reasoning* and *working collaboratively*, opportunities for the assessment of skills in *developing hypotheses*, *planning investigations* and *forming coherent arguments* were identified.

2. IMPLEMENTING THE INQUIRY AND ASSESSMENT UNIT

2.1 Activities for inquiry teaching & learning and their rationale

The four activities described in the **Food and food labels** SAILS inquiry and assessment unit were developed by the team at King's College London for use in the SAILS project. The unit is presented four activities (A-D), in which students are introduced to food groups and nutritional composition of foods. This is a topic that is revisited many times throughout a child's time in school and one of the main reasons for including it in the curriculum is the hope that children will begin to understand what makes a healthy balanced diet. From this stance, they can then look at their own diet and that of others and make recommendations about how to improve a diet. The problem however is that too often the ideas behind obtaining a balanced diet are not considered in sufficient detail to allow youngsters to understand what a balanced diet means in reality with foods simply categorised as healthy or unhealthy or as fat or protein and the true composition of foods and the amounts needed to keep someone healthy are not looked at. So students are not equipped with sufficient knowledge and skills to make the choices that they need to when it comes to their own diet. The activities presented in this unit aim to support students with developing better ideas about food and incorporate an inquiry-based approach to help students develop the requisite skills and also to motivate students to want to understand these ideas better.

Background Information

A healthy diet involves consuming appropriate amounts of all essential nutrients and an adequate amount of water. Nutrients can be obtained from many different foods, so there are numerous diets that may be considered healthy. A healthy diet needs to have a balance of fats, proteins, and carbohydrates, calories to support energy need and micro nutrients (vitamins and mineral salts) to meet the needs for human nutrition. Fibre in the diet also bulks the food intake and keeps the gut contents moving.

Guidelines have been established which detail the recommended quantities and ratios of nutrients that should be consumed, based on a calorific intake of 2,000 calories, for adults and children aged four years or older. The following tables list the daily values (DVs) for various food groups (Table 1) and recommended daily intakes (RDIs) for vitamins and minerals (Table 2). Implementation of this unit can begin with an introduction to nutrition and the food groups and use these tables as a focal point for discussions.

Table 1: Daily values (DVs) for various food groups

Nutrient	Daily value (DV)
Saturated Fatty Acids	20 g
Cholesterol	300 mg
Sodium	2400 mg
Potassium	3500 mg
Total Carbohydrate	300 g
Dietary Fibre	25 g
Protein	50 g

Table 2: Recommended daily intake (RDI) for vitamins and minerals

Nutrient	RDI	Nutrient	RDI
Vitamin A	900 µg	Biotin	300 µg
Vitamin C	60 mg	Pantothenic acid	10 mg
Calcium	1000 mg	Phosphorus	1000 mg
Iron	18 mg	Iodine	150 µg
Vitamin D	400 IU (10 µg)	Magnesium	400 mg
Vitamin E	30 IU	Zinc	15 mg
Vitamin K	80 µg	Selenium	70 µg
Thiamine (Vitamin B1)	1.5 mg	Copper	2 mg
Riboflavin	1.7 mg	Manganese	2 mg
Niacin	20 mg	Chromium	120 µg
Vitamin B6	2 mg	Molybdenum	75 µg
Folate	400 µg	Chloride	3400 mg
Vitamin B12	6 µg		

Activity A: Packed lunches

Concept focus	Comparing the nutritional content of different food items Calculations using ratios
Inquiry skill focus	Working collaboratively
Scientific reasoning and literacy	Scientific reasoning (proportional reasoning) Scientific literacy (evaluating the nutritional content of food)
Assessment methods	Classroom dialogue Teacher observation Worksheets

Rationale

The idea behind this activity is for students to begin comparing foods in terms of amount, energy values and composition so that they get the idea of proportional reasoning. This activity consists of a number of questions, which include calculations using ratios. It is recommended that the teacher does not provide hints or formulae, as this activity should develop skills in reasoning, rather than mathematics.

Suggested lesson sequence

1. The questions can be provided on a worksheet (Figure 1), orally by the teacher or on a projector (or other approach). Use the first few questions (Q1-3) as whole class activity, with students discussing answers in small groups and reporting back. It is a good idea to use mini whiteboards, voting systems or simply asking other groups to agree/disagree with answers and different ways of working out or articulating how they did each question. The teacher can focus in the interactions on "How did you work that out?" to get students to demonstrate their *scientific reasoning* capabilities. The teacher should take care not to provide formulae or hints, as this cuts short the students' reasoning and makes the task a simple mathematics problem.

2. Once the teacher is satisfied that students are capable of carrying out the mathematical manipulations, the next questions can be investigated. In these, students are asked to consider the nutritional content of food. Again, proportional reasoning is key, and the students use this to form comparisons between different food items.

3. To further develop students' understanding of food labels, an additional question can be posed. In this, students are given a sample food label (Figure 2).

4. A final task in this activity is to facilitate students working in pairs to use food labels to compare the amounts of carbohydrate or fat or protein. When you are sure they have some idea of proportionality ask them to prepare some questions for their peers. Ask students to judge which are the best questions to demonstrate that they can investigate data and use proportional reasoning.

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?
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?
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?
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
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 crisps contains the most fat?
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

Figure 1: Example of a student worksheet for Activity A: Packed lunches

7. A 125 g pot of fruit yoghurt has 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 2: Additional question for Activity A: Packed lunches

Activity B: Food cards

Concept focus	Comparing the nutritional content of different food items Introducing food groups – carbohydrates, fats and protein
Inquiry skill focus	Working collaboratively
Scientific reasoning and literacy	Scientific reasoning (proportional reasoning) Scientific literacy (evaluating the nutritional content of food)
Assessment methods	Classroom dialogue Teacher observation Worksheets

Rationale

The Food cards activity offers an opportunity to further develop students' skill in proportional reasoning. The students are asked to consider the nutritional composition of foods that they commonly consume, thus introducing a day-to-day application of this skill. This activity also supports the development of students' understanding of nutrition and making healthy food choices.

Suggested lesson sequence

1. Make some sets of food cards for a range of common foods, including banana and white bread. On the card, put the food name, amount usually consumed in a meal (in grams), amount of carbohydrate, fat and protein in 100 g of the food (Figure 3).
2. Give each pair of students a banana and a white bread food card. Ask them to compare the two foods. Write up the different comparisons on the board.
3. Give each group of students 3-4 more food cards and ask them to find the food with the highest amount of carbohydrate. Ask them to explain how they decided this. Collect the 3 highest cards in and display them so the whole class can see them
4. Now ask the students to find the food with highest protein content out of their remaining cards. Again ask them to explain their process and collect and display the 3 highest cards.

Food name:	*Banana (medium)*
Total amount (g):	*118 g*
Carbohydrates (g per 100 g)	*23 g*
Fat (g per 100 g)	*0.3 g*
Protein (g per 100 g)	*1.1 g*

Figure 3: Sample food card for Activity B: Food cards

5. Next ask them to find the food with highest fat content out of their remaining cards. Again ask them to explain their process and collect and display the 3 highest cards.
6. Ask each group to compare the food cards they still have with the high carbohydrate, high protein and high fat cards in the display. How much more of each food group do the "high" foods have?
7. Give each group a plate and ask them to select food cards that represent the foods in a typical meal. Ask them to work out how much carbohydrate, protein and fat the meal contains. Which foods contain most of the carbohydrate? Which foods contain most of the protein? Which foods contain most of the fat?

Activity C: The washing line

Concept focus	Carbohydrate, fats and proteins in the diet Comparing the nutritional content of different food items
Inquiry skill focus	Working collaboratively
Scientific reasoning and literacy	Scientific reasoning (proportional reasoning) Scientific literacy (evaluating the nutritional content of food)
Assessment methods	Classroom dialogue Teacher observation Worksheets

Rationale

In this activity, students consider their own diets, and can see if they are obtaining enough of the nutrients they need, or if their consumption is greater than what is recommended. Students evaluate the food labels of the foods they eat every day, and they examine its content in terms of carbohydrates, fats and proteins. This process supports them in making informed decisions about which foods they should eat more often, and those they should eat less of.

Suggested lesson sequence

1. Set up three pieces of string as washing lines over about a 2-3 m distance. Label one washing line "carbohydrate," the next "protein" and the final one "fat."
2. Give the students three copies of 5-6 food labels for common foods such as bread, chicken, beans, cereal, cheese, potato, tomato, yoghurt, and ask them to rank the foods based on the amount of carbohydrate, protein and fat from the data on the labels. Get the students to put the labels on the three washing lines, using pegs or paperclips, to show the different amounts of each food type. Mark the range and the midpoint with the values on each washing line.
3. Then ask them to pin up other labels (perhaps that they have brought in). How do these food compare with the ones they first placed up?

4. This activity can be developed to look at making changes in their diet. Get students to write out what they eat in a day listing each food or ingredient in a meal separately and ask them to use the details on the washing line to consider amounts of carbohydrate, protein and fat in each meal. The teacher can pose questions such as: "How might you increase the protein in your meal? How could you reduce the fat content of the meal? How could you spread the carbohydrates over more meals? What could you replace food X with, if you want to keep the same amount of protein but reduce the fat?" The key activity here is getting students to explain what each meal contains in terms of carbohydrate, protein and fat and how much of each of these is each food contributing to the meal. In this way, students begin to compare foods and learn how to make choices such as:
    - Cheese is high in protein but also high in fat. By swapping chicken for cheese, I still eat enough protein but take in less fat.
    - Low fat yoghurts reduce the amount of fat, but they still have quite high carbohydrate content in the form of sugars. I would be better having strawberries and plain low fat yoghurt rather than a low fat strawberry yoghurt.
    - A serving of spaghetti and tomato sauce has less carbohydrates and fat than a portion of chips. Both contain about the same small amount of protein.

There is opportunity with this topic to extend this activity further and consider questions such as:

- What are the amounts of carbohydrate, protein and fats in traditional dishes from each country?
- How can a vegetarian ensure sufficient protein in his/her diet?
- How might an athlete's diet differ from a normal diet?
- How to select foods for a day's hike which give a balanced diet but do not weigh too much in your rucksack.
- How might a small child's meal differ from that of an adult?

Activity D: Testing for vitamin C

Concept focus	Comparing the vitamin C content of different food items
Inquiry skill focus	Planning investigations Developing hypotheses Working collaboratively
Scientific reasoning and literacy	Scientific reasoning (recording data and observations)
Assessment methods	Classroom dialogue Teacher observation Worksheets

Rationale

Humans are recommended a daily intake of 60 mg of vitamin C. This is approximately a whole large mango or 125 g of pineapple. While this test cannot measure the exact amount of vitamin C in a food, it does provide a way of comparing high, medium and low values of vitamin C in different foods. In this activity, students' skills in *developing hypotheses* and *planning investigations* can be assessed.

Suggested lesson sequence

1. To start the activity, the teacher can demonstrate that a solution of vitamin C decolourises blue 2,6-dichlorophenol-indophenol (DCPIP) solution.
2. Students are asked to consider how they might carry out an investigation on how a person might obtain their daily dose of vitamin C. The teacher can ask some prompt questions, such as "Is it better to have fruit or juice? Juice or squash? Fresh fruit compared to cooked fruit?"
3. Students should first develop a hypothesis to test and then investigate it systematically.
4. Students should test 2 or 3 of the juices provided by the teacher in order to practice their technique (Figure 4), before investigating their own food choices. It should be clear to the students that this test allows them to compare the vitamin C content of foods.

For each group of students:

- Vitamin C solution, 1% (low hazard)
- 2,6-Dichlorophenol-indophenol (DCPIP) solution, 1% (low hazard)
- Graduated pipette, syringe or burette.
- 10 pipettes
- 10 test tubes and rack
- Fruit juice and squash samples
- Citrus fruits, apples, tomatoes

Figure 4: Materials required for testing for vitamin C in foods

2.2 Assessment of activities for inquiry teaching & learning

In this unit, the key skills developed are *scientific reasoning* and *working collaboratively*, and several opportunities for the assessment of these skills have been highlighted. For example, in Activity A: Packed lunches, the assessment of *scientific reasoning* can be achieved by listening to group discussion as they work out the answers to the questions posed and also when groups report back on their answers to the whole class. Questions 1-5 are relatively straightforward, while Questions 6 and 7 require higher order reasoning. Question 8 allows the teacher to differentiate the performance level of students within groups, by placing students in pairs and by the complexity of the food labels provided. The teacher should encourage the students to explain how they reach their answers and get them to compare their methods with those of other students. In this assessment, students' ability to articulate how they solved the problems is more important than obtaining the correct answer.

In this activity, the teacher should be able to distinguish between students that have the ability to:

- Work out proportions when quantities are doubled, halved or simple multiplication of original amount
- Manipulate proportions and explain how they did this (e.g. X in 40 g is 2.5X in 100 g or X in 40 g, so X/4 in 10 g which is 10X/4 in 100 g)
- Manipulate proportions for 2 or more variables and so can compare amounts of food types in food packets of different masses (X g of fat in a 75 g bag is more per 100 g than Y g of fat in a 60 g bag)

The students then use similar reasoning skills associated with proportionality in Activity B: Food cards and Activity C: The washing line, In addition, the student can demonstrate how they can make choices based on their proportional reasoning. The assessment can be carried out in a similar manner to that outlined for activity A.

A 4-level rubric for the assessment of *working collaboratively* is proposed (Table 3), which allows for the assessment of students' skill in collaboration and debating with peers.

In Activity D: Testing for vitamin C, students' skills in *developing hypotheses* and other investigative skills such as *planning investigations* and collection of data can be assessed. A sample rubric for the assessment of *developing hypotheses* is shown in Table 4.

Table 3: Rubric for the assessment of working collaboratively

Emerging	Developing	Crafting	Extending
The student makes suggestions.	The student makes suggestions and takes turns.	The student makes suggestions and listens and responds to suggestions of others.	The student makes suggestions and considers suggestions of others. Asks questions or makes statements that encourage the group to reflect or reach a collaborative decision

Table 4: Rubric for the assessment of developing hypotheses

Emerging	Developing	Crafting	Extending
The student tests a range of juices/squashes for vitamin C but does not form a hypothesis.	The student tests a range and asks which drink/fruit contains the most vitamin C?	The student suggests X contains more vitamin C then Y and carefully sets up the comparison with equal volumes (e.g. juice contains more vitamin C than squash/ fresh fruit contains more vitamin C than cooked fruit).	The student suggests X contains more vitamin C than Y, with scientific reasoning as to choice (e.g. heating destroys vitamin C) and sets up a fair test for this.

3. SYNTHESIS OF CASE STUDIES

This unit was trialled in four countries, producing five case studies of its implementation – **CS1 Turkey**, **CS2 Hungary**, **CS3 Ireland**, **CS4 Portugal** and **CS5 Hungary**. The case studies detail implementation at lower second level, as recommended in the unit, except in **CS4 Portugal** and one class in **CS5 Hungary**, which features a 9th grade class (upper second level). The ages of the students involved in the case studies were aged 11-19 years, thus teachers varied the implementation to suit the requirements of their respective class groups. The students in each class were mixed ability and mixed gender, except in **CS3 Ireland** where the students were all female. The case studies were implemented by teachers who had some experience of teaching through inquiry, but the students involved had generally not been taught through inquiry previously.

In **CS3 Ireland** and **CS5 Hungary** the selected inquiry activities were carried out in one lesson of 45-60 minutes. **CS1 Turkey** and **CS2 Hungary** implemented most elements of the unit over two 45-minute lessons. Finally, **CS4 Portugal** implemented one unit activity (food cards) over five lessons (60 minutes each).

The case studies detail a range of implementations and adaptations, and the skills assessed vary from focusing entirely on *working collaboratively* in **CS5 Portugal**, to assessment of each of the SAILS inquiry skills and competencies in **CS2 Hungary**. The assessment methods described include on-the-fly interactions and structured dialogue, teacher observation, evaluation of worksheets and student devised materials and self-assessment (in **CS4 Portugal**).

3.1 Teaching approach

Inquiry approach used

The inquiry approach used across the case studies was *guided inquiry*, as the teachers felt that they needed to introduce some ideas about nutrition and diet before the students commenced the activities. The teachers then set the inquiry question and the students worked collaboratively on the various activities.

Implementation

In all case studies, the students worked in groups (Table 5). All schools, except that of **CS3 Ireland**, were mixed gender, while the Irish school was a girls' school. No specific choices were made by the teacher as to how to group the students for these activities beyond whom the teacher felt would work well together.

In each of the case studies, the students explicitly or implicitly dealt with the concept of healthy diets and food choice. **CS2** and **CS5** (both **Hungary**) carried out most of the activities in the unit, with **CS5 Hungary** dividing some of the activities to be done by younger groups (Activity B: Food cards and Activity C: The washing line) and others for older groups (modified Activity B: Food cards and Activity D: Testing for vitamin C). In **CS5 Hungary**, students produced their own food labels by looking up food composition, when no food labels were available for the activity. Also in this case study, the teacher could not find a supply of chemicals for the vitamin C analysis and so decided to test foods for fat content instead. In the other case studies, the teachers chose particular aspects and activities for implementation. For example, **CS4 Portugal** focused on an adapted version of Activity B: Food cards, as this implementation

Table 5: Summary of case studies

Case Study	Activities implemented	Duration	Group composition
CS1 Turkey	Activities A, D	Two lessons (45 min each)	• Six groups of 5-6 students (35 students) • Teacher assigned; mixed ability and gender
CS2 Hungary	Activities A-D	Two lessons (45 min each)	• Individually and in six groups of 5-6 students (31 students total) • Teacher assigned; mixed ability and gender
CS3 Ireland	Activity B	One lesson (50 min)	• Groups of 3 students; single-sex (all-girls) • Teacher assigned; mixed ability
CS4 Portugal	Activity B	Five lessons (60 min each)	• Groups of 3-5 students (28 students; 12 boys, 16 girls) • Student selected; mixed ability and gender
CS5 Hungary	Activities B-D	One lesson (45 min)	• Groups of 3-4 students (two classes, 22-24 students) • Student selected; mixed ability and gender

was with an upper level student group, whom were addressing a real-world challenge. These students devised "healthy school snack" kits for adoption in their school, which does not have a student cafeteria. Similarly, in **CS3 Ireland**, the teacher adapted Activity B: Food cards for a discussion-based inquiry on "What do you think junk food is?" **CS1 Turkey** details implementation of Activity A: Packed lunches and Activity D: Testing for vitamin C, as these activities aligned well with the school curriculum and offered an opportunity for the teacher to assess students' research processes, rather than focus only on a final output.

Adaptations of the unit

While there were some changes made to the proposed teaching and learning activities to fit the context of the specific classroom, availability of resources or adaption to particular learning needs of students, the main concept of reasoning through discussion was described in all case studies.

In **CS2 Hungary**, the teacher modified the unit because the students were confident users of the tables of nutritional content and making food cards did not present a challenge to them. Therefore, the teacher devised more advanced versions of Activity B: Food cards and Activity C: The washing line, using an online database to analyse the lunch menu of the school with respect to calorie content and nutritional value. Having identified the key considerations for putting together a school lunch menu, the students were asked to suggest a three-course meal that they would suggest for the school menu. As outlined for activities B and C, this activity encouraged the students to consider the nutritional value of foods they encounter in their daily lives, and to make healthy food choices. In this school, it was not possible to carry out Activity D: Testing for vitamin C using DCPIP, instead the teacher used an alternative redox method using potassium iodide and starch indicator.

In **CS3 Ireland**, the teacher implemented Activity B: Food cards as an inquiry through discussion. The students worked in small groups to discuss and debate the inquiry question "What do you think junk food is?" A whole-class discussion was used to provide formative feedback.

In **CS4 Portugal**, the unit was implemented with an upper second level cohort in a vocational setting. Therefore, the teacher modified Activity B: Food cards to provide a challenge for these students – "How can we maintain healthy food habits if we do not have a cafeteria? How can we have proper snacks between main meals at a low cost and without compromising the nutritive and hygienic quality of food?" To address this, students were asked to propose a "healthy school snack" kit that could be introduced in their school. The implementation took place over five 60-minute lessons, with the first lesson dedicated to defining the problem and discussing assessment criteria. Three further lessons were used to develop proposals (suggested meal, nutritional data for all components, health and hygiene considerations) and in the final lesson students presented and discussed their proposals.

CS5 Hungary describes implementation in two separate classes, where the teacher adapted the unit for use with upper and lower second level students. Again, Activity B: Food cards was modified to include use of an online database to search for information on nutritional composition of foods from daily life. However, the most significant adaptation was for Activity D: Testing for vitamin C. As the reagent DCPIP was not available, the teacher revised this task to test for fats instead. The students had recently learned to separate mixtures and they were able to select and follow the procedure to separate fat. In this way, the teacher was able to assess students' skills in *developing hypotheses* and *planning investigations* during this activity, as outlined in the assessment of inquiry teaching & learning section of this unit.

3.2 Assessment strategies

While, for several of the classes, an inquiry learning approach was a relatively new approach, it was clear that the teachers had begun to look at opportunities for formative assessment as well as documenting summative achievements. Perhaps one of the most relevant findings was that students enjoyed and were motivated by the inquiry activities and the teachers seemed relatively confident in both facilitating the inquiry and assessing it.

In the various implementations, several different approaches to assessment were taken and different skills were identified for assessment (Table 6). All case studies used the context of nutrition and making food choices to introduce the topic, but did not necessarily assess students on this, instead focusing on development of inquiry skills. Most commonly used assessment methods were on-the-fly interactions, structured dialogue and evaluation of students' worksheets or other artefacts.

Table 6: Inquiry skills identified by teachers in the case studies

CS1 Turkey	• Developing hypotheses • Working collaboratively • Scientific reasoning (proportional reasoning, drawing conclusions)
CS2 Hungary	• Developing hypotheses • Planning investigations • Forming coherent arguments • Working collaboratively • Scientific reasoning (proportional reasoning, collecting data) • Scientific literacy (analysis and interpretation of data)
CS3 Ireland	• Forming coherent arguments • Working collaboratively (debating with peers) • Scientific literacy (understanding the nutritional composition of food and making informed food choices)
CS4 Portugal	• Working collaboratively • Scientific reasoning (problem-solving)
CS5 Hungary	• Planning investigations • Working collaboratively • Scientific reasoning (making reasoned decisions) • Scientific literacy (critical thinking; collection and analysis of scientific data)

In **CS1 Turkey** the teacher chose to implement Activity A: Packed lunches to assess students' *scientific reasoning* capabilities, in particular proportional reasoning. The teacher expected that students would develop understanding of proportional reasoning, but did not identify any success criteria or performance levels for this skill. During Activity D: Testing for vitamin C, the teacher was able to assess students' skills in developing hypotheses and *working collaboratively*. The teacher used on-the-fly interactions to provide formative feedback, in particular for lower-performing students. In addition, teacher observation was used to assess performance in *working collaboratively*. The teacher chaired a structured whole-class discussion at the end of the lesson, in which the students explained and presented their research approach to the class, while the teacher participated only as an observer.

The teacher in **CS2 Hungary** took a different approach to assessment, combining both formative and summative assessment. The teacher collected individual student worksheets and graded their work for Activity A: Pack lunches to assess proportional reasoning and analysed the distribution of grades (by student and by question) to identify weaknesses to be addressed. For the assessment of students' skills in *planning investigations, forming coherent arguments* and *working collaboratively*, the teacher devised 4-level rubrics, such as that shown in Table 7.

In the vitamin C investigation, different groups required different amounts of input from the teacher when *planning investigations*. This is reflected in the assessment rubric that the teacher developed. In addition, in this case study the teacher assessed *scientific literacy*, through considering the students' skill in implementation, data collection and the analysis and interpretation of scientific data. 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 and enabled the teacher to act formatively in response to the assessment evidence.

In **CS3 Ireland**, the emphasis of the implementation was on development of students' skill in *working collaboratively*, with some observation of the skill of *forming coherent arguments*. The teacher listened to the group discussions and used professional judgement to decide how successful individual students were in contributing to the discussion. The ability of the whole group to form a joint decision was also noted. At the same time, the teacher observed the quality of the discussion towards *forming coherent arguments*.

In **CS4 Portugal**, the teacher chose to focus on the skill of *working collaboratively*, while challenging the students to develop a proposal for a well-adjusted snack, suited to the energy needs of teenagers, and according to the taught contents. A 4-level rubric was prepared, which features criteria for success in both teamwork and debating with peers (Table 8). The criteria were shared with the class before commencing the activity, and the teacher used an observation grid to observe frequency of behaviours during implementation (Table 9). She also expected the students to be able to demonstrate their analysis and interpretation of the data contained in the food composition table, and also to support their snack proposal in class. By listening in to the group discussion, she was able to judge whether they achieved this or not. Afterwards, each group presented their own proposal to the class, which offered another opportunity for assessment. Students completed a self-assessment questionnaire, which addressed their opinions on working as part of a team.

At the end of this activity, the students submitted a comprehensive report to the teacher, for summative assessment purposes. Included in the rubric for the assessment of this report was a criterion for "group work" which was worth 15% of the overall grade. For this criterion, the teacher used observation notes from the lessons to assign a performance level. The students' skills in problem-solving, an aspect of *scientific reasoning*, were developed throughout this activity, but this was not assessed formally.

Table 7: Assessment of forming coherent arguments in CS2 Hungary

Skill	Emerging	Developing	Consolidating	Extending
Drawing conclusions	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
Making reasoned decisions	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.

Table 8: Rubric for assessment of working collaboratively in CS4 Portugal

Skills	Emerging	Developing	Consolidating	Extending
Teamwork Interpersonal relationships and group functioning (emotional literacy)	Observes and accepts the colleagues' proposals in the organisation of the group work, but gives no suggestions; merely accepts what the colleagues are doing (due to difficulties in interpersonal relationships).	Participates in the organisation of the group work, but only makes one or two suggestions that add little value to what was already done (due to difficulties in interpersonal relationships).	Participates in the organisation of the group work and gives positive suggestions contributing to a productive group dynamic.	Participates in the organisation of the group work and significantly contributes to a productive group dynamic, creating positive personal interactions (allowing the improvement of others and raising the work level).
Debating with peers (discussion)	Presents the obtained results without explaining how they were achieved.	Presents the results and describes how they were obtained.	Presents the results and explains the reasoning for obtaining them.	Presents the results, explains the reasoning for obtaining them and discusses those results.

Table 9: Registration grid for assessment of working collaboratively in CS4 Portugal

Behaviour	Student x	Student y	...
Does not interrupt when others speak			
Questions the colleague regarding what he is saying			
Defends his points of view			
Talks with kindness			
Challenges a quieter colleague to speak			
Congratulates colleagues when they present a positive idea			
Assumes an active role in order to solve conflicts between colleagues			
Defines/clarifies the work's objectives			
Defines/distributes/negotiates tasks among colleagues			
Draws attention to time			
Faced with distractions draws the group's attention to the work			

CS5 Hungary used a criterion-referenced approach and devised 4-level rubrics for the assessment of inquiry skills (Table 10). Critical thinking, which is an important component of the 21st century skills set and a pertinent part of *scientific literacy*, was assessed during Activity B: Food cards and Activity C: The washing line. For the most part, groups were assessed but the teacher managed to assess a few individuals as well. *Scientific reasoning* (making reasoned decisions) builds on critical thinking, and was assessed through teacher observation during Activity B: Food cards. During Activity D: Testing for fats, the students worked in teams to plan an experiment to establish the fat content of a particular food. During this task, the teacher could assess skill in both *planning investigations* and *working collaboratively*.

In both **CS3 Ireland** and **CS5 Hungary**, students used a placemat/window to record individual contributions and to decide on a group response (Figure 5). These were evaluated by the teacher to assess how the students cooperated and collaborated. In this way, it was possible for the teacher to evaluate student performance individually and as a group.

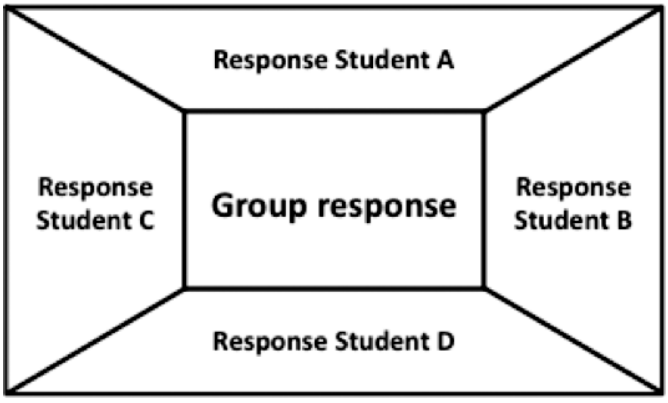

Figure 5: Placemat/window for peer discussion

Table 10: Assessment of skills in CS5 Hungary

Skill	Emerging	Developing	Consolidating	Extending
Critical thinking (scientific literacy)	Correctly orders a sufficient number of food cards for each nutrient with no interpretation.	Correctly orders a sufficient number of food cards for each nutrient, draws appropriate conclusions about individual groups of nutrients and occasionally about combinations of 2 nutrients.	Correctly orders all available food cards and draws appropriate conclusions for a combination of 2 or 3 groups of nutrients. Brings up considerations of quantity in discussion.	Correctly orders all available food cards and draws appropriate conclusions about all groups of nutrients in combination. Makes a valid point about quantity in discussion.
Scientific reasoning (making reasoned decisions)	Mentions ideas but does not write them down. Does not respond to the arguments of others.	Mentions ideas and occasionally writes them down. Occasionally responds to the arguments of others.	Speaks and writes ideas in the form of decisions and occasionally supports these ideas with arguments. Represents a critical stance in discussion.	Speaks and writes ideas in the form of decisions and invariably supports them with appropriate arguments. Adopts or refutes others' arguments as appropriate.
Planning investigations	Does not have any ideas about how to plan the investigation or actively participate in the teamwork. Follows the calculation of the answers passively.	Has some ideas about how to plan the investigation and what method to use but has no confidence in implementation. Needs help to calculate the answers.	Chooses an appropriate method of investigation and can support the choice with arguments. Can plan the details of the investigation. Can calculate the answers correctly.	Speaks and writes ideas in the form of decisions and invariably supports them with appropriate arguments. Adopts or refutes others' arguments as appropriate.
Working collaboratively	Written communication lacks confidence, information or is entirely absent. Communicates more fluently in speech but lacks purpose.	Communicates fluently in writing but some information is missing. Attempts to express independent opinion but lacks confidence. Oral communication is more fluent and usually has purpose.	Communicates fluently in writing and expresses independent opinion with confidence. Communicates fluently and with purpose in speech but the arguments are not always apt. Listens to others and occasionally reflects on their opinions.	Communicates fluently in writing and expresses independent opinion with confidence. Communicates fluently and with purpose in speech and presents apt arguments. Listens to others, reflects on their opinions, shows flexibility and gives in to arguments if appropriate.