4.2 Case study 2 (CS2 Slovakia)

Concept focus	Transformation of sol-gel Nutritional balance of proposed recipe
Activities implemented	Activities A-C
Inquiry skills	Planning investigations Forming coherent arguments Working collaboratively
Scientific reasoning and literacy	Scientific reasoning (argumentation)
Assessment methods	Classroom dialogue Teacher observation Student devised materials (pudding) Other assessment items (homework exercise)
Student group	**Grade:** upper second level (Gymnasium) **Age:** 15-16 years **Group composition:** co-ed class, but single sex groups **Prior experience with inquiry:** No

This case study details an interdisciplinary implementation, in which teachers from both chemistry and biology asked students to investigate the sol-gel transition in a pudding, as well as its nutritional value. The skills identified for assessment were *planning investigations*, *working collaboratively and forming coherent argument*s. Assessment was based on teacher observation and classroom dialogue, during which students explained how they optimised their puddings in terms of thickener/fluid ratio and nutritional composition.

(i) How was the learning sequence adapted?

Biology as a subject did not have a two-hour lesson period, therefore when the unit was piloted the first part of inquiry was carried out at home (Activity A: Preparing the inquiry). The aim of the dialogue was to consider the sol-gel transition using the example of the pudding. Students were also asked to consider the nutritional value of foods, for example:

- Do you like pudding?
- What is your favourite?
- What consistency should it have?
- Do you prefer stiffer or more cream?
- Upon what does the consistency of the pudding depend?
- How is it possible that cooking will turn a liquid to a gel state?
- What thickeners do you know?
- Do you have experience with cooking puddings?
- How would you prepare a pudding at home, if you did not have custard powder from the store?
- What materials would you need?
- What if someone has lactose intolerance or coeliac disease? What pudding could he eat without problems?

The students found out that within a few days they would cook a pudding using their own recipe. The criteria were set – the pudding should be tasty, nutritious, have a proper density and the thickener may not be bought in the store. They could review the nature of transition sol-gel phases from chemistry and explain why the pudding thickens after cooking and hardens upon cooling.

The students worked in groups – one pair of boys, four pairs of girls, one trio of boys and one trio of girls. Trios were created in order to avoid a mixed gender pair. Students were asked to bring

ingredients (starch, flour, gelatine or agar of their own choice) for the next lesson, cook their pudding at school and defend its composition in terms of nutritional value.

(ii) Which skills were to be assessed?

The teachers determined that the core skills to be assessed were *planning investigations*, *working collaboratively* and *forming coherent arguments*. In addition, students gained experience in weighing, measuring volume, searching for information and *developing hypotheses*, but these skills were not assessed.

Teachers from both biology and chemistry were present when students investigated the actual final weight, consistency and taste of their puddings and discussed the results in terms of the nutritional value of the product. They assessed students' skills in determining the optimum ratio of fluid to thickener (*planning investigations*) and optimum nutrient balance (*forming coherent arguments*). During the discussion and experiment, the teachers evaluated whether or not the students were able to agree on the procedure and coordinate activities (*working collaboratively*).

As mentioned, the experiment was implemented by two groups of boys and five groups of girls. Gender did not play a role in students' motivation and initiative for the tasks assigned as homework. On the contrary, the effect of dividing the groups by gender was motivating and was reflected in the rivalry of boys versus girls, which continued throughout the lesson. The boys sought to prove that they could cook better puddings and the girls looked for accuracy in testing the stiffness of the product and adhering to the recipe. After tasting the products, students had to express, in written form, if they noticed a difference between each groups' work, and how they assessed the products of boys and girls. Only two cases (in one case a pair of boys, in the second, a pair of girls) assessed performance of boys and girls as equal in general. The other groups said that girls were better, more skilled and smarter than boys. This assessment may be based on prejudice that women generally have more experience in cooking.

(iii) Criteria for judging assessment data

It was clearly demonstrated from the discussion at the beginning of double lesson that students paid more attention to looking for a recipe than planning the experiments focused on the ratio of liquid and thickener. Although they carried out this step, they did not properly record their findings and report accurately about it. We expected that students would record the process and their observation data in a table, as was recommended in the introductory discussion. We assumed that they had experience with similar record keeping and that they would be able to propose the table independently. However, this did not happen and their records took the form of ordinary notes.

Furthermore, we expected that in designing of the recipe the students would (1) consider custard powder and the method described on the bag, or (2) describe the first recipe for pudding that they found on the Internet. However students surprised us, when they started to find the best recipe from their families and find familiar old traditional recipes for a tasty pudding. We expected that students would have problems agreeing on a procedure, recipe and coordination of work during the lesson and at home, when working in groups, but this did not occur. The initial tasks that were assigned for homework required cooperation, which the students achieved very well.

During cooking the pudding, we expected that students would not weigh raw materials accurately, but they managed this activity very well. Furthermore we expected that they might have a problem with the technological process – which was confirmed in two cases – but it resulted in arguments about what ingredient add to what ingredient, if is better to add milk to weighed flour/starch or on the contrary, and why. Student argumentation was assessed as very good. The line of argumentation was associated with properties for the various compositions and solutions – swelling, aggregation tendency of the beads to thicken and other factors.

We assumed that students would bring a record of the testing that took place at home, using a table format and that it would be possible to assess their procedures based on these artefacts. However, the students did not attribute importance to writing a clearly arranged procedure and results.

The skills related to the weight of the pudding were not paramount, but we assumed that it would be possible to connect them to assessment of argumentation. Argumentation is also developed in the final activity of this lesson, when students discuss the taste, nutritional value, consistency and final weight of the puddings that the teams have cooked.

(iv) Evidence collected

Teacher opinion

The students were enthusiastic; they enjoyed the inquiry and competed among groups (Figure 1). They asked when they could have another inquiry lesson and they talked about inquiry to classmates who did not participate in this activity (the second half of the class). Students were interested in the practical aspects of the lesson, but they have linked it less with theoretical knowledge of biology and chemistry than expected. For example, they considered that ensuring that the final product was exactly 500 g to be far more important than maintaining a proper ratio of protein, carbohydrates and fat in their recipes. We assume that this was mainly because the students were experiencing inquiry for the first time. The method was new for them and it was difficult for them to focus on skills that are directly related to inquiry.

After this experience, the teachers prepared a model table to record observations. They decided that during planning and recording of data they would assess how students designed their own data collection form, if it is in the planning of research or just for writing the data collected during the realisation of research.

The teachers were in favour of the procedure and selected raw materials. Students did not choose gelatine or agar as a thickener, but instead they worked with starch and flour. They defended the importance of other ingredients, such is a butter, cocoa or sugar. Students argued why inclusion of some ingredients may result in a change of the resulting consistency of pudding compared to the baseline test of stiffness, for example cocoa caused the pudding to become more concentrated, fruit juice diluted it and other similar observations.

Figure 1: Examples of the final pudding and student engaged in working collaboratively in CS2

(v) Use of assessment data

The teachers identified that it is necessary to lead students to plan their methods of observation and to consider how to record measured data in a table format. They also recognised that it is necessary to guide the students to use spreadsheet software or other digital tools in biological research. The teachers found out that that the group of students cooperated very well.

(vi) Advice for teachers implementing the unit

We recommend that new teachers give more attention to planning. If students have no experience with *planning investigations*, they might need to receive an outline or guidance from the teacher. Students may not realise that it is important to test conditions for transition from one phase to another phase (sol-gel) and so they might not consider it. They also underestimate the importance of keeping a clear, detailed record of procedures or of results. Therefore, it is better to perform this part of the research in school, not at home. With regard to biological content (nutritionally balanced food) it would be useful to discuss with them the importance of sugars, fats, proteins, vitamins and fibre in foods during the introductory discussion at the start of the lesson. We expect that this would lead to more precise scientific arguments when defending their own recipes.